Final Report

A project under the Canada
New Brunswick Conservation
and Renewable Energy
Demonstration Program

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POSTAL CODE E3B 5B4 TELEX 014-46238

N.B. 78

FEASIBILITY STUDY FOR A MODEL WOOD ENERGY INDUSTRY

REPORT COMPILED BY
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FREDERICTON, N.B.
OPERATION IMPROVEMENT LIMITED
EDMUNDSTON, N.B.

1983

Canada/New Brunswick Conservation and Renewable Energy Demonstration Program

The Conservation and Renewable Energy Demonstration Program is administered in New Brunswick by the Energy Secretariat and managed jointly with Energy, Mines and Resources Canada. The Program is designed to help demonstrate promising conservation and renewable energy technologies, to develop public awareness and understanding of these technologies, and to create employment in new or existing industries.

Through over 100 demonstration projects in New Brunswick, a wide variety of conservation and renewable energy technologies have proven to be technically sound and economically attractive. These demonstration projects should now provide a catalyst for commercialization and lead to widespread adoption of many of these proven technologies.

This final report is based on a project which was financially supported by the Energy Demonstration Program. For further information on other demonstration projects funded in New Brunswick under this program, contact:

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Feasibility Study for a Model Wood Energy Industry

Final Report

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Feasibility Study for a Model Wood Energy Industry

1. Summary and Conclusions

1.1 General

This study indicates that there are definite opportunities for the establishment of a wood energy supply industry in the south-central region of New Brunswick. A financial analysis of five business models indicates that three specific businesses are economically viable. These are:

- a Wood Chip Supply Business
- a Sawmill Residue Supply Business
- a Fuel Wood Supply Business

Implementing the businesses would require invested capital of $416,000 for the Wood Chip Business, $647,000 for the Sawmill Residue Business and $265,000 for the Fuel Wood Business which would yeild discounted cash flow returns on investment of 65%, 71% and 77% respectively.

1.2 Markets

The geographic area serviced by the businesses would be Kings and Queens counties. A review of the potential wood energy market in this area shows that there is a sufficient market for and interest in wood energy fuels to support either a Wood Chip or Sawmill Residue Supply Business plus a Fuel Wood Supply Business. Sales volume projections are based on

replacing approximately 11% of the existing petroleum products used for heating purposes in the study area. Sales prices for the wood energy fuels which would provide attractive financial returns to the consumers have been used.

The Wood Chip or Sawmill Residue Supply Businesses would sell their products primarily to industrial, agricultural and larger institutional consumers of petroleum products while the Fuel Wood Supply Business would sell primarily to residential consumers.

1.3 The Supply

There are adequate supplies of raw materials within the study area to support each of the businesses on a continuing basis. It should be noted however, that there is a trend developing in which sawmills contract to supply their wood residues directly to pulp and paper mills and some other large consumers. Therefore, a Sawmill Residue Supply Business must assure itself of an adequate, long term source of supply before committing any funds to the business.

1.4 Business Types

Five business models were prepared for this study. Three of the models would supply semi-processed wood fuels to consumers in the form of green wood chips, hogged sawmill residues, and cut and split fuel wood. Two of the models would supply processed wood fuels in the form of dried wood chips and wood fuel pellets.

1.5 Financial

Five year proforma profit statements for each business model were prepared and the sensitivity of the models to changes in sales prices and

volumes was analysed. The economics favour the three models which supply semi-processed wood fuels. These are the Wood Chip, Sawmill Residue, and Fuel Wood Supply Businesses. Each of these businesses provide excellent returns on investments and have good margins of safety to accomodate reductions in sales prices and volumes.

2. The Industry

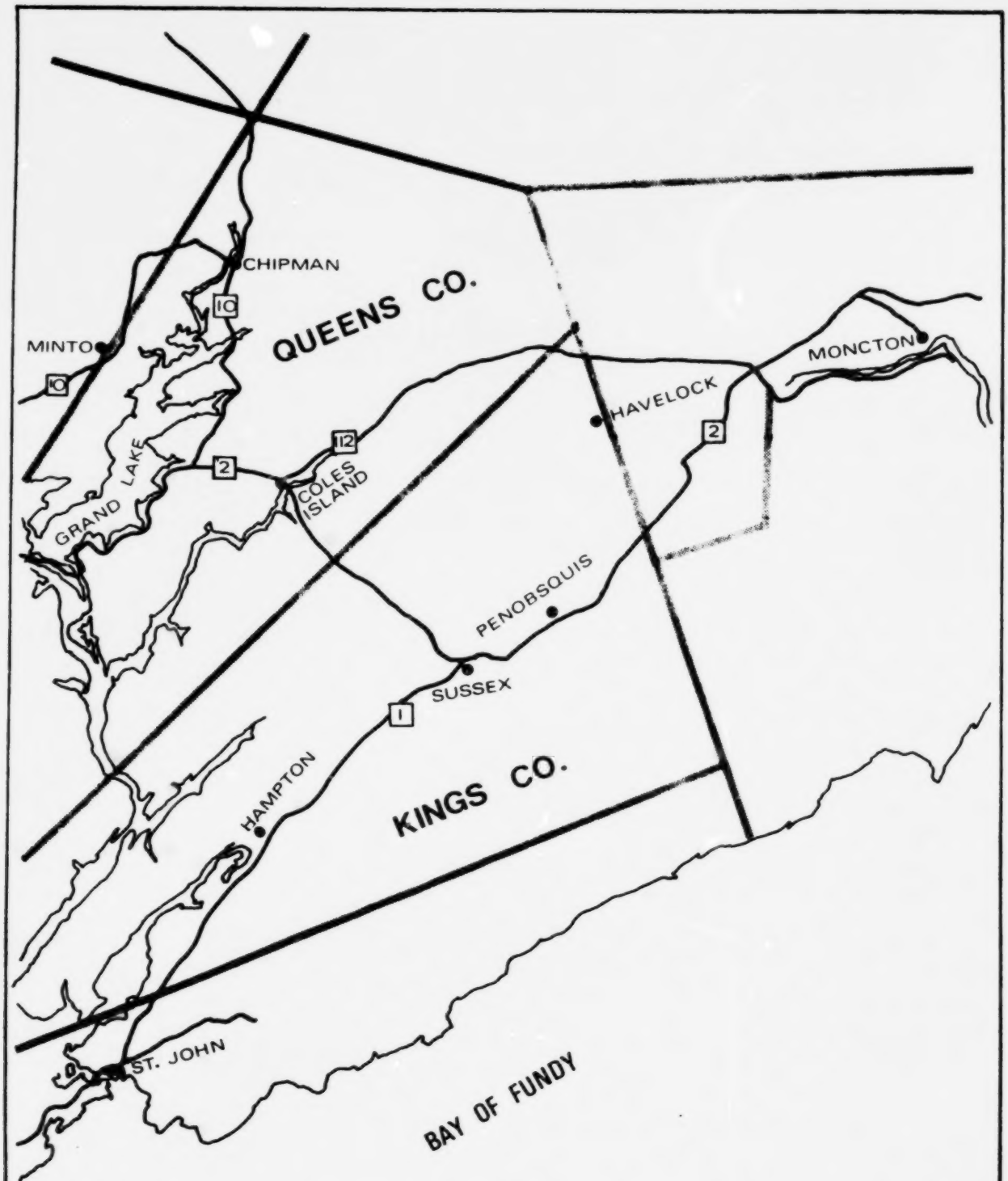
This study examines the potential for the establishment of an industry which could supply wood energy fuels to consumers in south central New Brunswick whenever economically feasible. The market area for the industry would consist mainly of Kings and Queens Counties and would be centered in the Sussex region. The industry could supply wood energy fuels to residential, commercial, institutional, industrial and agricultural establishments either as a primary or secondary heating fuel to replace petroleum products or electricity. The fuels could be in the form of roundwood, chunkwood, chips, pellets and residuals such as bark, sawdust and shavings. The industry may also have to, or wish to, supply supporting services to its customers in the form of maintenance contracts, periodic furnace and flue cleaning, personnel training, and technical and financial assistance with furnace conversions or installations.

The economy of the south central area of New Brunswick is predominantly agricultural in nature with a lower per capita energy consumption than the average for the Province of New Brunswick and a wide geographic dispersion of consumers. However, the energy consumers in the area generally have a high level of interest in wood energy and a good understanding of the requirements for its successful use.

A small wood energy industry already exists in the area. It consists of the traditional residential fuel wood market and a number of small woodlot owners and pulp wood harvesters who are developing a market for wood energy fuels in the agricultural and institutional areas. There is a potential for expanding the wood energy industry through an aggressive marketing plan directed at the industrial, agricultural, institutional and residential consumers in the area. The

existing forest harvesting industry in the study area has all the capabilities necessary to undertake this expansion and is currently seeking new opportunities for wood fuel sales. The existing supply of wood energy fuels in the area is sufficient to support a substantial increase in their use. This supply consists of underutilized species and manufacturing residuals primarily from small sawmilling operations.

The study area is shown on the following page.



STUDY AREA	NEILL AND GUNTER LIMITED		
	DATE JUNE 09/83	SCALE ~	JOB No. 3071
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TRANSTEX 10

3. The Market

In this section the total energy consumption in the study area is examined, together with the distribution of the consumption by the major traditional economic sectors. These economic sectors are defined as industrial/agricultural, commercial/institutional, and residential consumers.

Typical consumers in each sector have been contacted to determine the type of heating plants currently in use, the consumption patterns of these plants and any physical, environmental or personnel constraints which could affect the installation of a wood energy heating plant.

3.1 Energy Consumption

In order to assess the market potential for wood energy fuels the existing energy consumption in the study area was examined. A number of Provincial and Federal agencies were contacted for information on consumption patterns in the study area. Unfortunately this type of data is not readily available for energy products other than electricity. All of the current statistics are prepared on a province wide basis and detailed data by counties or regions is not compiled at this time.

A rough approximation of the energy consumption market has been made by applying the average per capita energy consumption for the Province of New Brunswick[1] to the population of the study area[2]. The distribution of this consumption by the major traditional economic sectors, excluding the transportation sector, is also estimated by using the average distribution of consumption for the Province of New Brunswick[1]. The results of these calculations are given in Table 1.

(1) Numbers in parentheses refer to literature cited at end of report.

Table 1

Estimated Energy Consumption by Sector - 1980, First Approximation

Kings and Queens Counties

Tera Joules

Sector	Wood	Wood Residues	Petroleum[a] Products	Electricity	Total
Industrial & Agricultural	0	1592	4550	1507	7649
Commercial & Institutional	0	0	1529	502	2031
Residential	520	0	1595	764	2879
Total	520	1592	7674	2773	12,559

(a) For Heating Purposes.

Source: Energy Secretariat, New Brunswick Energy Review, 1982.
Statistics Canada, 1981 Census of Canada, Cat. 93-904

It was realized that Table 1 was a very rough approximation since the calculations assume that the total energy consumption and the distribution of the consumption in the study area follow the provincial pattern. The estimates contained in Table 1 were checked by obtaining the electrical energy consumption and the distribution of that consumption by sector for the Sussex District of the New Brunswick Electric Power Commission[3]. This datum indicated that the industrial/agricultural and commercial/institutional sector consumptions were considerably lower than the estimates contained in Table 1 while the residential consumption was within 10% of the Table 1 estimate. This probably follows from the fact that the study area is less industrialized than the provincial average. The energy consumption estimates for all types of energy were adjusted in proportion to the actual electrical energy consumption for each sector and are restated in Table 2.

Table 2

Estimated Energy Consumption by Sector, Adjusted

Kings and Queens Counties

Tera Joules

Sector	Wood	Wood Residues	Petroleum Products[a]	Electricity	Total
Industrial & Agricultural	0	474	1354	448	2276
Commercial & Institutional	0	0	692	227	919
Residential	472	0	1447	693	2612
Total	472	474	3493	1368	5807

(a) For heating purposes.

It should be noted that the figures for petroleum products include only those products which are normally used for heating purposes. These are; light fuel oil and kerosene, heavy fuel oil, and propane and butane.

3.2 The Potential Market

The potential market for wood energy fuels would be as a replacement for petroleum products and electrical energy which are used for heating purposes. Table 3 indicates, for each sector, the percentage of total energy consumption that each energy source contributes:

Table 3

Consumption by Energy Source

Per Cent of Total

Sector	Wood	Wood Residues	Petroleum Products	Electricity	Total
Industrial & Agricultural	0.	8.2	23.3	7.7	39.2
Commercial & Institutional	0.	0.	11.9	3.9	15.8
Residential	8.1	0.	24.9	12.0	45.0
All Sectors	8.1	8.2	60.1	23.6	100.0

Source: Table 2

The distribution of energy consumption by source of energy indicates that the major market potential for wood energy fuels is in the replacement of petroleum products and to a lesser extent in the replacement of electricity. The following discussions on electrical energy consumption in these sectors serves to emphasize the importance of the petroleum products market.

(a) **Industrial and Agricultural**

Electrical energy consumption in the industrial and agricultural sectors is normally used for lighting, electrical power for equipment operation and specialized process heating. For these reasons, industrial consumption of electrical energy is not considered as a potential market for wood energy fuels. This does not exclude the possibility that a particular electric heating process could be replaced by wood energy.

(b) **Commercial and Institutional**

Electrical energy in the commercial and institutional sector is used primarily for lighting and equipment operation and secondarily for building heating, domestic hot water heating and other process heating. Our examination of typical building electric heating systems in a number of institutions and commercial enterprises indicates that they are primarily of the baseboard convector or unit heater type. These are expensive to convert to a central heating plant, which would be required for a wood energy based heating system. The potential for the replacement of electrical energy with wood energy is limited to special cases such as major domestic hot water heating plants.

(c) **Residential**

Electrical energy consumption in the residential sector is used for three major purposes; lighting and appliances, domestic water heating, and space heating. The typical distribution of this consumption is shown in Table 4.

Table 4

Distribution of

Residential Electricity Consumption

% of Total

	Electric Heated Homes	Oil & Wood Heated Homes	Average[a] for All Homes
Lighting and Appliances	26.1	61.3	45.0
Domestic Hot Water Heating	16.4	38.7	24.9
Space Heating	57.5	0.0	30.1
Total	100.0	100.0	100.0

(a) 20% of the homes are electrically heated.

Source: New Brunswick Electric Power Commission

The main potential for replacement of electrical energy consumption with wood energy appears to be in homes with electric space heating. However, the majority of residential electric space heating systems use baseboard resistance heaters, and conversion of these homes to central wood energy heating systems would not be economical. Neverthless, there is a market to replace or supplement electric space heating with small air tight stoves using round wood.

(d) **Summary**

In summary, the greatest market for a wood energy fuel industry is in the replacement of petroleum products. If the total petroleum products consumption shown in Table 2 is converted to wood fuel, the consumption would be approximately 233,000 bone dry tonnes per year. This conversion is based on heating plant efficiencies of 80% for oil and 60% for wood fuel at 50% moisture content wet basis.

3.4 Specific Markets

A partial list of energy consumers in each of the economic sectors was compiled from the various sources[4][5][6][7]. The lists for the industrial and agricultural and institutional sectors are contained in Appendix 1. The major consumers in each of these sectors were contacted to determine their petroleum products consumption. The specific market potential for each of the sectors is discussed in the following sections.

3.4.1 Industrial and Agricultural

(a) **Industrial**

The Directory of Products and Manufacturers lists 64 enterprises in Kings and Queens Counties which employ about 1200 people. Fourteen of the major enterprises are listed in Table 1.1, Appendix 1. These enterprises employ about 700 people or 58.3% of the total work force. Two of the enterprises listed were the J. D. Irving sawmills in Sussex and Chipman which employ about 195 people. These two enterprises were not considered as potential consumers because they are capable of supplying their own wood energy fuels from the residues generated in the mills. This leaves twelve enterprises which employ approximately 42% of the work force listed in the directory.

These twelve enterprises consume the equivalent of approximately 77,000 bone dry tonnes of wood fuel per year. Most of their energy consumption is for process heating which provides a steady demand throughout the year.

(b) **Agricultural**

The Department of Agriculture lists approximately 65 enterprises in the poultry, hog and greenhouse sectors of the agricultural business in Kings and Queens counties. The consumption data for these facilities is incomplete because we have not been able to obtain detailed energy consumption data from the individual consumers. Marketing efforts in this subsector will require extensive personal contact with these consumers. One major industrial poultry operation was visited to obtain consumption data. This consumer expressed a high level of interest in wood heating.

3.4.2 Institutional

The institutional sector consists of educational, health services, public and other buildings. A list of the major buildings in each of these areas is included in Appendix 1 and are summarized below.

(a) **Educational Buildings**

The study area includes school districts 18, 19, and part of districts 16 and 24. The total petroleum products consumption by these school districts is 67 TJ per year or the equivalent of 4,400 bone dry tonnes of wood fuel per year. The largest individual consumers are Kennebecasis Valley High at an equivalent of 880 bone dry tonnes per year and Sussex Junior High and Sussex Regional High at an equivalent of 630 and 510 bone dry tonnes per year respectively.

(b) **Health Service Buildings**

There are five health service related facilities in the study area. The two facilities which reported their oil consumption consume the equivalent of 433 bone dry tonnes per year.

(c) **Public Buildings**

There are nine public buildings of significant size in the study area. Data for these facilities is incomplete.

3.4.3 Residential

There are approximately 19,500 households in Kings and Queens Counties[2]. The number of households using the various types of energy for space heating and domestic hot water heating has been estimated by using the average distribution for the Province of New Brunswick.

Table 5

Residential Use of Heating Fuels

(Number of Households Using Fuel as Primary Heat Source)

	Oil	Electricity	Wood	Total[a]
Space Heat	11,400	3,900	4,200	19,500
Domestic Hot Water	6,800	12,000	400	19,200

Source: Statistics Canada, Household Facilities and Equipment, Cat. 64-202, May, 1982.

[a] Variations in the totals are the result of variations in statistical data and the exclusion of bottled gas for domestic hot water heating.

It is estimated that the 6,800 households which use oil fired domestic hot water heaters consume a total of 187 TJ per year. This estimate is based on an average consumption of 27,600 MJ per year per household at a 60% average annual efficiency for the oil fired heaters. The total residential petroleum products consumption for the study area has been estimated to be 1447 TJ (Table 2). Subtracting the domestic hot water heating requirements from this total leaves 1290 TJ of energy consumption for space heating. This has a wood energy equivalent of approximately 84,000 bone dry tonnes per year, assuming an oil combustion efficiency of 80% and a wood conbustion efficiency of 60%.

3.4.4 Summary

The energy consumption market in Kings and Queens counties consists mainly of small consumers. This applies to all of the economic sectors with the exception of several major industrial consumers. This fact will restrict the size of the wood energy industry because it will be more difficult to convince large numbers of small oil and electrical heat energy consumers to convert to wood energy use. It is estimated, from the datum shown in Table 6, that a new wood energy industry could achieve an 11.0% share of the total existing petroleum products market. This estimate is based on the following assumptions.

(1) The sales of wood stoves for residential use are continuing at approximately 80% of the peak sales volume of two years ago which indicates that residential consumption of wood fuels is continuing to increase.

(2) Aggressive marketing techniques by the wood energy industry should convince 15% of the industrial and agricultural, and 5% of the commercial and institutional market to convert to wood fuel heating.

(3) A sufficient number of viable opportunities have been identified in the study area to support this volume of sales in the non-residential sectors.

A summary of the total estimated wood energy market in the study area is given in Table 6. The total estimated market consists of existing wood energy use plus the estimated new market. The potential market consists of all the estimated petroleum products consumption in the study area converted to equivalent wood energy.

Table 6

Estimated Wood Energy Market

Bone Dry Tonnes/Year

Sector	Potential Market	New Market Share	New Market	Existing Market	Total Market
Industrial/ Agricultural	90,300	15%	13,545	1,300	14,845
Commercial/ Institutional	46,100	5%	2,305	300	2,605
Residential	84,000	10%	8,400	23,600	32,000
Total	220,400	11.0	24,250	25,200	49,450

3.5 Wood Fuel Sales Prices

A range of maximum wood fuel sales prices that could be achieved by the wood energy industry has been determined by examining several applications for wood energy heating plants in the study area. Typical consumers in each of the economic sectors were selected for the study. In each case, the installed cost, operating costs and the wood fuel consumption for the heating plant were estimated. A wood fuel price which would yield a 15% to 20% after tax rate of return was calculated from this datum. The details of each case are contained in Appendix 1 and are summarized in Table 7 below.

Table 7

Estimated Wood Fuel Sales Prices

	Class	Load Factor	$/bone dry tonne	
			Chips (50% M.C.)	Roundwood (30% M.C.)
Case I	Industrial	33.3%	43.61	
Case II	Industrial	96.3%	64.53	-
Case III	Residential	8.4%	20.45	-
Case IV	Residential	8.4%	-	62.20
Case V	Residential	14.3%	-	60.34
Case VI	Agricultural	66.9%	43.31	
Case VII	Agricultural	66.9%	45.15	

The variations in the maximum wood fuel sales prices shown in Table 7 result from several heating plant cost factors which are important considerations for the wood energy industry. These factors are:

- Fuel storage facility costs
- Heating plant load factor
- Operating labour costs

The cost of a wood fuel storage silo and the associated outfeed equipment is a significant portion of the overall heating plant costs. In some cases, a storage facility which provides one week of inventory at the peak plant consumption rate can cost as much as the wood energy fired boiler. This cost relationship will vary with the size and complexity of the storage facilities. The profitability of the wood fueled heating plant is greatly reduced if additional labour, as compared to an oil fired plant, is required for its operation. A heating plant which has a high load factor will provide the best return on investment and can afford to pay the highest fuel prices. The load factor is defined as the average annual plant heat output devided by the peak plant heat output. A plant with a high load factor operates at close to full capacity over a large percentage of the year which means that the equipment is fully utilized. Conversely, a low load factor means that the facilities are underutilized and during a large percentage of the year much of the investment is not earning savings in fuel costs. The implications of these cost factors for the wood energy industry are:

- Look for applications with high load factors. These are normally found in industrial plants with a process heat load. However, a high load factor for a wood fueled furnace can also be achieved by combining it with an existing oil fired unit in such a way that the

wood fueled furnace provides a relatively steady base load and the oil fired unit supplies the peak loads. Two examples of this type of application are shown in Cases VI and VII in Appendix 1.

- Look for potential consumers who do not need extensive fuel storage facilities. These would be residential and other consumers who could use roundwood, and agricultural consumers who would have material handling equipment such as tractors for feeding day storage bins.
- Look for applications which minimize the need for additional operating labour.

3.6 Wood Fueled Heating Equipment

Wood energy fuels can be burned in a wide range of combustion equipment. The type of equipment which is selected for a particular application will depend on the type and form of the fuel, the heating medium, the heating capacity and output control required, and the economics and convenience of the particular installation. The combustion equipment can be classified in several ways.

(a) **Heating Medium**

(1) Hot air

(2) Hot water

(3) Steam

- low pressure
- high pressure

(b) **Type of Combustion Cell**

(1) Suspension burning

(2) Grate burning

(3) Pile burning

(4) Gasifiers

Some of these can be further divided into single cell or multiple cell burners.

The following sections briefly describe the more common and conventional types of combustion equipment which may be used for wood energy heating. A more detailed review of this equipment is given in references 15 and 16 of Section 9.

3.6.1 Residential

Residential wood fueled heating equipment usually consists of the following types.

(a) **Chunkwood Stoves**

These are normally single chamber, pile burning units, which radiate heat from the stove surfaces to the building space. A small fan and hot air heat exchange surface may be included to increase the heat output and a catalytic converter may be added to increase the combustion efficiency. The stoves must be fed by hand and heat output is controlled by manually adjusting the combustion air inlet or by a bimetallic thermostat and combustion air damper mounted on the stove. These are

the typical air-tight wood stoves which are used for supplemental space heating.

(b) **Chunkwood Furnaces**

These are generally single chamber, pile burning units, which transfer heat to a hot air or hot water jacket for distribution through the building by ducts or pipes. These units are somewhat similar to the conventional oil fired hot air or hot water furnaces used for central heating. These furnaces must be fed by hand and the heat output is controlled by a space thermostat which opens the combustion air damper on the furnace, and by a thermostat in the furnace jacket which controls the hot air or hot water circulator.

(c) **Wood Chip Furnaces**

These are generally single chamber, grate burning units, which transfer heat to a hot air or hot water jacket for distribution through the building by ducts or pipes. These units are very similar to the conventional oil fired hot air or hot water furnaces. The fuel feed is automatic using a mechanical conveyor from a fuel storage hopper into the furnace. The fuel is burned on a metal grate and a combustion air fan feeds a portion of the combustion air under the grate so that it moves through the fuel bed and the balance is supplied above the grate to complete the combustion of the fuel. The

grates can be underfed, overfed, and spreader types. With the underfed grates, a screw conveyor brings the fuel under the grate and forces it up through a hole in the center of the grate where it spills onto the grate. With the overfed grates, a screw conveyor drops the fuel onto the top of the grate in a pile. With the spreader grates, a portion of the combustion air is used to blow the fuel onto the grate. This type of feed tends to spread the fuel evenly across the grate and a portion of the fuel is burned in suspension.

The heat output from the furnace is normally controlled by a space thermostat which starts and stops the fuel feed conveyor, combustion air fan and circulators while a second thermostat in the furnace jacket and a timer starts and stops the fuel feed to maintain a constant flame in the furnace.

3.6.2 Non-Residential

The types of combustion equipment which could be used by commerical/institutional and industrial/agricultural consumers is largely dependent on the furnace capacity and the type of heating medium.

(a) **Wood Chip Furnaces**

The wood chip furnaces of the types described in Section 3.6.1 (c) above are available in capacities from 150 up to 4000 Mega Joules per hour. The larger sizes

are available with mechanical dust collectors and are normally hot water or low pressure steam boilers. These units are suitable for small to medium scale space heating applications.

(b) **Wood Fueled Boilers**

Wood fueled boilers are single cell or multiple cell types and are available in capacities from 500 Mega Joules per hour to 60,000 Mega Joules per hour and generate hot water, low pressure steam, high pressure steam, or hot oil. They use a grate burning system with either an underfeed, overfeed, or spreader feed. In the single cell boilers, the combustion takes place in a single combustion chamber which may either form part of the heat transfer unit, be mounted directly under the heat transfer unit or be mounted beside the heat transfer unit with the flue gases being ducted from the combustion cell into the heat transfer unit. In the multiple cell boilers the fixed carbon portion of the fuel is burnt in the primary chamber and the volatile portion is gasified and carried into a subsequent chamber or chambers where secondary air is added to complete the combustion of the volatiles. The heat transfer unit generally forms the secondary and subsequent combustion chamber and may also form part of the primary combustion chamber. Multiple chamber boilers, due to their increased sophistication, have a higher

initial cost than single chamber units but provide higher combustion efficiencies, better load control, and can burn fuel with a higher moisture content.

The wide variety of wood fueled combustion equipment which is available can present a confusing picture. The selection of a wood fueled boiler or furnace for a particular application must be made with a thorough understanding of the user's requirements, the fuel type and condition, and the overall economics of the application. The New Brunswick based manufacturers of wood fueled combustion equipment are listed under boilers and furnaces in the "Directory of Products and Manufacturers, New Brunswick, Canada" which is published by the Department of Commerce and Development, Province of New Brunswick.

4. The Supply

4.1 Sources of Fuel Types

The two major groupings of fuel types are residues from wood processing mills and biomass from the forest. Mill residues can include:

- bark
- sawdust
- shavings
- slabs
- chips.

Forest biomass includes:

- tops and branches of merchantable softwood and hardwood
- non-commercial species, partially rotten boles of commercial species that would be classified as culls for conventional markets and unusable portions of burned logs
- trees removed from stands during precommercial and commercial thinning and conversion cut operations.

In other words, the potential source of fuel from the forest is all biomass not presently used for commercial products such as sawlogs, pulpwood, pulp chips, poles, and veneer logs.

There are ten wood processing mills[8] of significant size and approximately 678,000 hectares of forested land in the study area[9] which are potential sources of supply for wood fuels. The following sections provide a detailed review of the quantities of fuels available from each of these sources.

4.2 Quantity of Supply

4.2.1 Sawmill Residues

The quantity of residues produced by seven of the ten wood processing mills in the study area was obtained through interviews with company representatives and inspection of the facilities. Annual production figures and the processing equipment used were checked to verify the residue production estimates given by the companies. In the mills that are not presently selling their residues, accurate quantitative data was not available and their residue production has been estimated. In these cases, weight trials would have to be conducted before implementation of the wood energy industry. The total quantity of mill residues which may be available for wood energy use is shown in Table 8 below.

Table 8

Sawmill Residue Availability

Bone Dry Tonnes/Year

	Produced	Currently Sold	Potentially Available
Chips	33,000	33,000	0
Sawdust	13,200	9,460	3,740
Shavings	5,085	1,170	3,915
Bark	13,500	3,825	9,675
Slabs	4,648	2,324	2,324
Total	69,433	49,779	19,654

The major mill residue producers in the study area are the J.D. Irving Ltd. sawmills at Sussex and Chipman. The Irving group is currently selling most of their residues to pulp and paper mills,

smoke houses and to industrial boiler plants in New Brunswick and the State of Maine. In the near future, they will be using these residues for the new hog fuel boiler at their pulp mill in Saint John and for this reason, their residues have not been included in Table 8.

Although a majority of the bark and sawdust residues are currently sold, the transportation distances from the producer to the consumer are so large that the profits from the sale of these residues are minimal, if existant at all. Therefore, given the same or higher sales price, a portion of these residues which are currently being sold to Georgia Pacific Corporation in Woodland, Maine could be available to a local wood energy industry.

4.2.2 Forest Biomass

The study area is within Region III of the Department of Natural Resources and contains approximately 678,000 hectares of forested land[8] of which 649,000 hectares is classified as productive forest. Details of the forest area classification for Region III are contained in Table 2.2 in Appendix 2. It should be noted that almost all of the Region III crown land is located in the study area. The annual quantity of forest biomass which is theoretically available from this forested area depends on the quantity of sawlogs, pulp wood and fuel wood harvested, the inventory of non-commercial species, and the amount of precommercial and commercial thinning and conversion cut residues produced.

The quantities of commercial softwood and hardwood species and fuel wood harvested in the study area were obtained from the Department of Natural Resources and are given in Table 9. Estimates of the mass of biomass left on site after roundwood harvesting operations range from 45% to 67% of the merchantable mass removed[13,14]. In this study, we have used a residue mass equal to 50% of the merchantable mass. No data has been obtained for the mass of residues available from precommercial and commercial thinning operations. The maximum available quantities of biomass from these sources are summarized in Table 9.

Table 9

Maximum Available Forest Biomass

Bone Dry Tonnes/Year

Source	Annual Allowable Cut	Present Annual Cut	Unused Annual Cut	Harvesting Residuals from Cut	Available Biomass
Softwood	330,660	330,660	0	165,330	165,330
Hardwood	149,280	55,650	93,630	69,399	163,029
Fuel Wood (a)	18,490	18,490	0	9,245	9,245
Poplar	55,650	0	55,650	27,825	83,475
Total	554,080	404,800	149,280	271,799	421,079

(a) Based on permits issued for cutting on Crown Land. Fuelwood cutting on freehold lands could be two times this value.

The available biomass quantities shown in Table 9 are a total of the residues generated from existing harvesting operations, assuming a residue mass equal to 50% of the harvested mass, plus the unused portion of the annual allowable cut for each source plus the residues generated from cutting the unused portion. In the case of commercial hardwoods, approximately 10,480 bone dry tonnes are harvested by whole tree chipping which does not leave any significant residues.

Approximately 50% of the maximum available forest biomass is in the form of residues from existing pulp wood and sawlog harvesting operations. About 57% of these harvesting operations are short wood or tree length harvesting methods which leave the tops and branches in the forest. At the present time, the costs of gathering this material from the forest for wood fuel purposes exceeds the market price for the fuel. However when the cost of removal and chipping of slash is weighed against the cost of subsequent silvicultural operations, this operation may become economically attractive. Approximately 43% of the harvesting operations use a full-tree to roadside harvesting method which brings most of the slash to a concentrated area. The Energy Secretariat of the Province of New Brunswick is currently funding a study to determine the costs of gathering the residues from these operations.

The second largest source of biomass for fuel purposes consists of under-utilized residual hardwood left standing after softwood harvest and stands of unused hardwood species. These sources may be economically recovered for wood fuel purposes if roundwood harvest and whole tree chipping operations are combined, and therefore represent a major potential source of wood fuels. A large percentage of these stands are on crown lands and freehold lands which are controlled by the major forest products manufacturing firms who may wish to retain these stands for their own use. Another portion of these stands is in small woodlots. Biomass harvesting costs are expected to be considerably lower on large areas than on small freehold lands because of economies of scale. However, operation methods for biomass removal from private woodlots will be investigated with the aim of maximizing return to the woodlot owner. Table 10 summarizes our current estimates of the actual mass of forest biomass which is economically recoverable for wood fuels.

The quantities of forest biomass shown in Tables 9 and 10 are based on a number of data sources and assumptions. We believe that these tables are sufficiently accurate for the purpose of this study since the estimated total mass of recoverable forest biomass is 370 percent greater than the estimated additional demand for this biomass.

Table 10

Estimated Recoverable Forest Biomass

Bone Dry Tonnes/Year

Source	Maximum* Quantity	Percent Recoverable	Recoverable Quantity
Softwood Residues	165,330	43(a)	71,092
Hardwood Residues	22,584	0(c)	0
Hardwood Standing + Residues	140,445	20(b)	28,089
Fuel Wood	9,245	0(c)	0
Poplar	83,475	20(b)	16,695
Total	421,079	27.5	115,875

*Source: Table 9

This table is based on the following assumptions:

(a) Forty-three percent of the current softwood harvesting operations in the study area use the full-tree to roadside method which would provide harvesting residuals which could be economically recovered.

(b) Twenty percent of the unused hardwood species would be available for wood fuel harvesting.

(c) These residues are left at the stump or the volumes are too widely dispersed to be economically recoverable.

4.3 Cost of Supply

4.3.1 Mill Residues

The residues from wood processing mills are by-products resulting from the processing operation. The sales value to the processing mill for each type of residue is determined by the

available market for the residues, the price which the customers are willing to pay and the transportation costs from the mill to the customer. Wood chips and shavings are high value residues which are sold to pulp and paper mills, composition board mills, smoke houses, and agricultural operations. Most of these residues are currently sold. Sawdust has a lower sales value and there is a limited demand for this residue in the pulp and paper and board industry. Sawdust is currently sold to local farmers for bedding material or is sold along with bark as hog fuel. Bark has the lowest sales value of the mill residues. Some mills are continuing to dispose of this residue through burning in teepee burners or by land filling; the others are using it themselves or selling to others for energy production at a price which covers the mill's storage and loading costs or disposal costs. Table 11 summarizes the current sales prices of the mill residues.

Table 11

Current Sawmill Sales Prices for Residues[a]

Type	Range $/Bone Dry Tonne
Chips	50 - 70
Shavings	5 - 6
Sawdust	3 - 4
Bark	1 - 3

[a] excluding cost of delivery to consumer.

4.3.2 Forest Biomass

The cost of production of wood fuels from forest biomass depends on the stumpage fees, the types of biomass harvested and the method of harvesting. The gathering of tops and limbs left in the

forest after short wood and tree length harvesting operations is expensive and should be combined with the harvesting operation where possible. The cost of chipping tops and branches from full tree to roadside operations is currently being examined in a study funded by the Energy Secretariat. The costs of full-tree chipping of residual hardwood stands and of roundwood harvesting have been obtained from current operations in the study area. Slash-chipping costs are estimated from a small-scale study conducted near Douglas, New Brunswick[12]. The roadside costs of the various forest biomass fuels are summarized in Table 12.

Table 12

Forest Biomass Production Costs

$ Per Bone Dry Tonne

	Range $/Bone Dry Tonne
Harvesting Residues[a]	
- shortwood	62 - 90
- full-tree to roadside	33 - 35
Full-tree Chips	28 - 30
Fuelwood (8')	34 - 36

[a]Costs of harvesting and extraction of merchantable wood, roads, and delimbing are not included. Cost reduction for subsequent silviculture operations is not included.

5. Operating Models

5.1 Harvesting Systems

The harvesting systems, methods and machinery chosen depend on the market price of the fuelwood chips, storage location and facilities, and volume of chips required. The harvesting systems include the following: full-tree chipping of pure hardwood stands; full-tree chipping of residual hardwood stands; chipping of tops and branches left after a full-tree to roadside softwood harvesting operation; chipping of tops and branches left on-site after a tree-length or trail-cut softwood harvesting operation; chipping of non-merchantable trees extracted from precommercial, semi-commercial and commercial thinnings and conversion cuts. The methods and equipment include the following: extracting by cut and skid operations; extraction by forwarder; use of small, portable chipper by private woodlot owner; use of industrial chipper by contractor.

Six basic biomass harvesting systems which could be used by the wood energy industry are described in the following sections. The harvesting costs and the sourses of data for each of the harvesting systems described are contained in Table 13.

5.1.1 Chipping

(a) Pure Hardwood Stands

Full-tree chipping of pure hardwood stands results in the lowest cost per tonne of chips produced because of the high production potential. Extraction of trees occurs either by skidder or forwarder. If skidders are used, however, chipper downtime for knife changes will increase by a factor of three because of dirt and rocks picked up by the branches.

A flow chart for a full-tree hardwood chipping operation is shown in Figure 1.

Production levels for this type of operation are approximately 45 green tonnes per productive hour. Down time may be from 30% to 50%, depending on the operating efficiency of the chipper, productivity of the harvesting and extraction activities, scheduling of chip vans, on-site maintenance facilities, and parts inventory.

(b) Residual Hardwood Stands

The harvesting methods and costs for full-tree chipping of standing residual hardwood stands are similar to those for pure hardwood stands; the major difference being the volume and number of stems per hectare. Costs may be slightly higher because of the larger distances between trees.

If harvesting and extraction of these residuals were combined with softwood harvesting operations, the costs of this centralized tree processing system may be reduced. A flow chart for this operation is shown in Figure 2.

(c) Tops and Branches at Roadside

Chipping of roadside slash is comparable in cost to full-tree chipping operations. This operation may be combined with full-tree to roadside harvesting operations or the slash sold to an independent chipping contractor after the completion of harvesting activities. A flow chart for this operation is shown in Figure 3.

A system of independent chipping contractors and a defined value for logging slash is well suited to private woodlot operations, where the amounts of slash produced per day are not large enough to justify having a chipper on-site during harvesting operations. Discussion with Mr. Lawrence McCrae, a woodlot owner in the study region, and an active member of the Southern New Brunswick Woodlot Owners Association, indicates that interest in this possibility is high.

(d) Tops and Branches on Site

This is a much more expensive operation than full-tree chipping because of the lower solid wood content processed per productive machine hour. However, this type of chipping operation uses material that would otherwise be burned or impede silviculture activities. A flow chart for this operation is shown in Figure 4.

(e) Chipping from Thinnings

Production and cost trials should be performed in order to obtain accurate data. Indications are that production costs are much greater than current market prices, and that it is not practical to extract and chip trees felled in precommercial thinnings at this time.

5.1.2 Roundwood

Harvesting of hardwood stands in roundwood form would be carried out by conventional cut and skid methods. Delimbing could be done at the stump or at roadside. A flow chart for the operation is shown in Figure 5. In the case of roadside delimbing, the operation could be combined with roadside chipping of tops and branches.

FIGURE 1

OPERATION FLOW CHART

FULL TREE CHIPPING

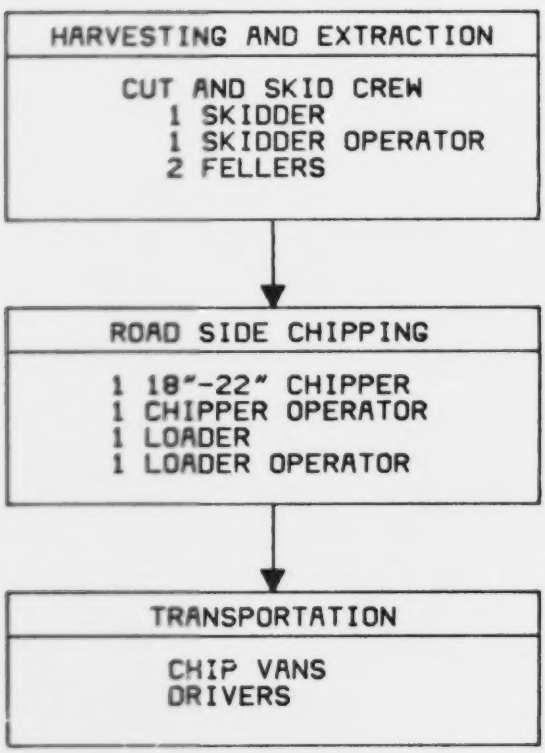


FIGURE 2

OPERATION FLOW CHART

COMBINED ROUNDWOOD AND CHIPPING

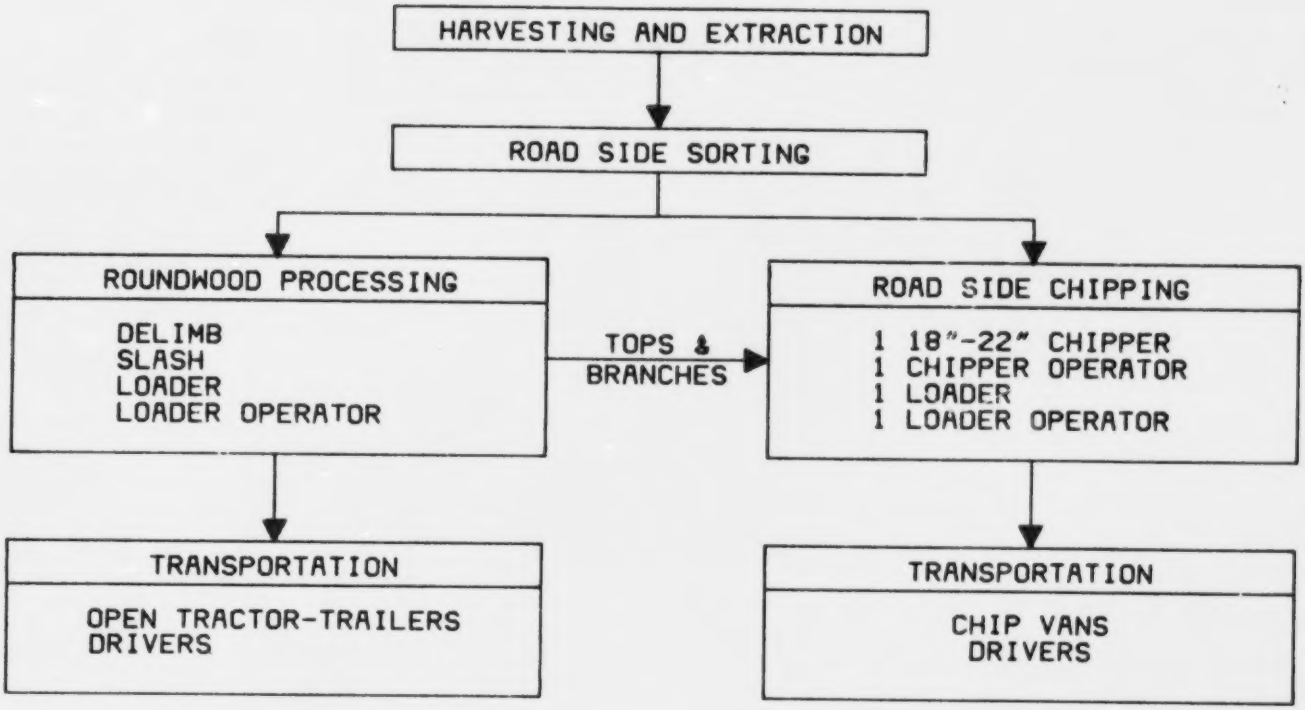


FIGURE 3

OPERATION FLOW CHART

CHIPPING TOPS AND BRANCHES AT ROAD SIDE

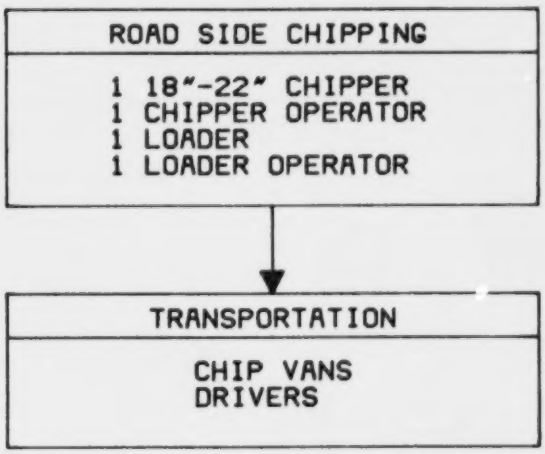


FIGURE 4

OPERATION FLOW CHART

CHIPPING TOPS AND BRANCHES LEFT ON SITE

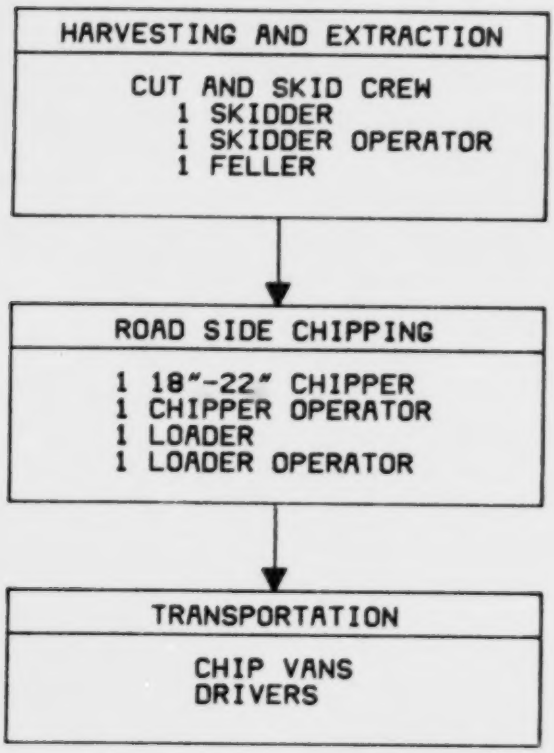
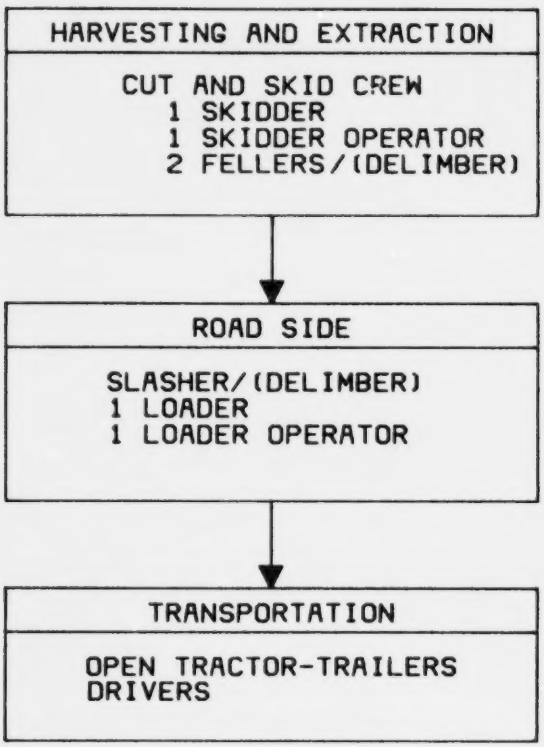


FIGURE 5

OPERATION FLOW CHART

ROUNDWOOD HARVESTING



Production costs for the various harvesting methods loaded in the chip vans or on open trailers are summarized in Table 13. The most economical harvesting methods are full-tree chipping of pure and residual hardwood stands and chipping of tops and branches left at roadside from full tree to roadside wood harvesting operations. These three operations are the only ones considered for the model wood energy industry since there are sufficient quantities of these materials available to satisfy the industry's needs.

Table 13

Wood Fuel Harvesting Costs

$ Per Bone Dry Tonne

	Pure & Residual Hardwood Stands - Full Tree -		Tops & Branches At Roadside	Tops & Branches On Site		Roundwood
	Forwarder	Skidder		Skidder	Winch	Skidder
Stumpage[d]	4.39	4.39	0	0	0	4.18
Harvest & Delivery to Roadside	13.40	12.00	0	28.00	56.00	28.32
Road Costs	2.00	2.00	0	0	0	2.00
Chipping & Loading	10.00	10.00	34.00	34.00	34.00	0.50
Total	29.79[a]	28.39[b]	34.00[a]	62.00[a]	90.00[c]	35.00

Sources:

(a) B. Chisholm, Valley Forest Products G. van Raalte, Maritime Forest Research Center.

(b) C. Martin, Ripples, N. B. & Levy, Southern N.B. Forest Products Cooperative, Sussex,

(c) Savage & O'Hara[12]. This test was performed by students. A commercial operation would have a higher productivity and lower costs.

(d) Department of Natural Resources, 1983-84 Royalty Rates.

5.2 Seasonal Factors

Seasonal factors affect both the supply and demand aspects of the Wood Energy Industry. The volume of residues from wood processing mills is strongly dependent on the market demand for the primary product. In the case of forest biomass, seasonal considerations include the following: machine maintenance requirements and down-time increase in the winter, harvesting and delivery operations are weather-dependent and are greatly affected by winter conditions, and spring weight restrictions can curtail transportation. On the demand side, user needs vary according to purpose and season. Industrial users, such as mills, factories, and processing plants require a relatively constant supply of fuel whereas institutional or residential users who require fuel mainly for space heating purposes will have a demand affected by the season and ambient temperatures.

5.2.1 Sawmill Residues

The larger sawmills operate 44 to 48 weeks per year during good market conditions. However some of the smaller mills in the study area are seasonal, operating only 6-8 months per year, thus decreasing the amount of available residues during these periods. In addition, spring weight restrictions on highways curtail transport by tractor-trailers or increase unit transport costs.

5.2.2 Forest Biomass

Production of wood chips for fuel will follow a seasonal pattern similar to conventional harvesting operations. Because of weight restrictions, fully loaded chip-vans are not allowed on

major highways from mid-March to mid-May. At the present market price for residues, it may not be economical to schedule chip-vans carrying less than full capacity, nor to load vans from anything other than the chipper directly, so chip production for large consumers may possibly cease at this time. Chip loading into smaller transport vehicles, such as dump trucks, may still occur.

5.3 Transportation

Transportation of wood chips is currently carried out using conventional chip vans, "live-bottom" chip vans, and dump trucks. The type of vehicle used will depend on the volumes handled and the distance from the supplier to the user. The costs per tonne-mile are shown in Table 3.1 in Appendix 3.

Both types of chip vans, with maximum capacities of approximately 15 bone dry tonnes of chips, are used when delivering to large industrial users. The use of conventional chip vans requires that the user have unloading capabilities while the use of live-bottom vans and dump trucks does not have this requirement. The purchase price of vans are $24,000 for conventional and $30,000 for "live-bottom". Dump trucks are generally used for transporting residues from small mills to small users, over distances less than 50 km. Most of the transportation is performed by independant truckers.

It is generally agreed that trucking is a major component of the wood chip production-delivery system, as the chips must be blown directly into a van or truck. Any additional handling or storage increases production costs above the value of the product. Much of the lost time

may be accounted for by delay in available trucks. Valley Forest Products solves this problem in their whole-tree chipping operations by scheduling one-more van than is calculated as required, but this may not be feasible for a smaller operator.

5.4 Processing

The raw wood energy fuels from mill residues and biomass harvesting require further processing before they can be delivered to consumers. The type and degree of processing required depends on the nature of the fuel, the consumer requirements relative to fuel particle size and moisture content, and any additional processing such as drying and pelletizing which would either improve the industry's profits or increase its sales volume by creating additional markets for the fuel. The processing options considered are described in the following sections.

5.4.1 Particle Sizing

The consumers who will use fuel chips and mill residues require a product free from large particles which would cause problems with jamming, plugs or bridging in the fuel storage and handling equipment. Therefore, the fuel chips from full tree chipping and chipping of harvesting residuals should be screened prior to delivery to the consumer. This can be done at the chipper. Sawmill residues will be obtained from smaller mills and will not be hogged. This material must be processed through a wood waste hog to reduce it to a suitable particle size. Since the sawmill residues can contain very large chunks of wood from butt ends of logs, a scalping will be required before the hog to

remove this material. Therefore, two essential elements of the processing system are: a scalping screen and wood waste hog for mill residues and a screen for chips.

5.4.2 Drying

Fuel moisture content is important from several aspects. Roundwood and chunkwood should be air dried prior to use by consumers. Wood chips and mill residues sold to residential consumers should be dried to prevent health problems which could be caused by fungi in this fuel. Drying of wood chips and mill residues to a specified maximum moisture content would simplify fuel deliveries if the fuel is sold on a weight basis since variations in moisture content would not be a factor. Drying would also increase furnace efficiencies resulting in increased fuel savings for the consumer and higher fuel sales prices.

Drying can be accomplished by forced air circulation through a covered fuel storage pile or by using a mechanical dryer with a hot air heating medium. The mechanical dryers have higher production rates and can produce lower moisture contents. A mechanical drying system will require less raw material inventory than a forced air circulation system due to its higher drying rate. We have used a mechanical dryer for this study.

5.4.3 Pelletizing

Pelletizing of wood chips and wood residues is practiced in a number of locations in Canada and the United States. This system combines the size reduction and drying equipment discussed above with a high pressure compaction unit to produce a product with low moisture content and high density. This product has the advantages of producing higher furnace efficiencies, reduced storage volumes and ease of handling. We have reviewed the capital and operating costs of a pellet system and the results are indicated in the section on operating models.

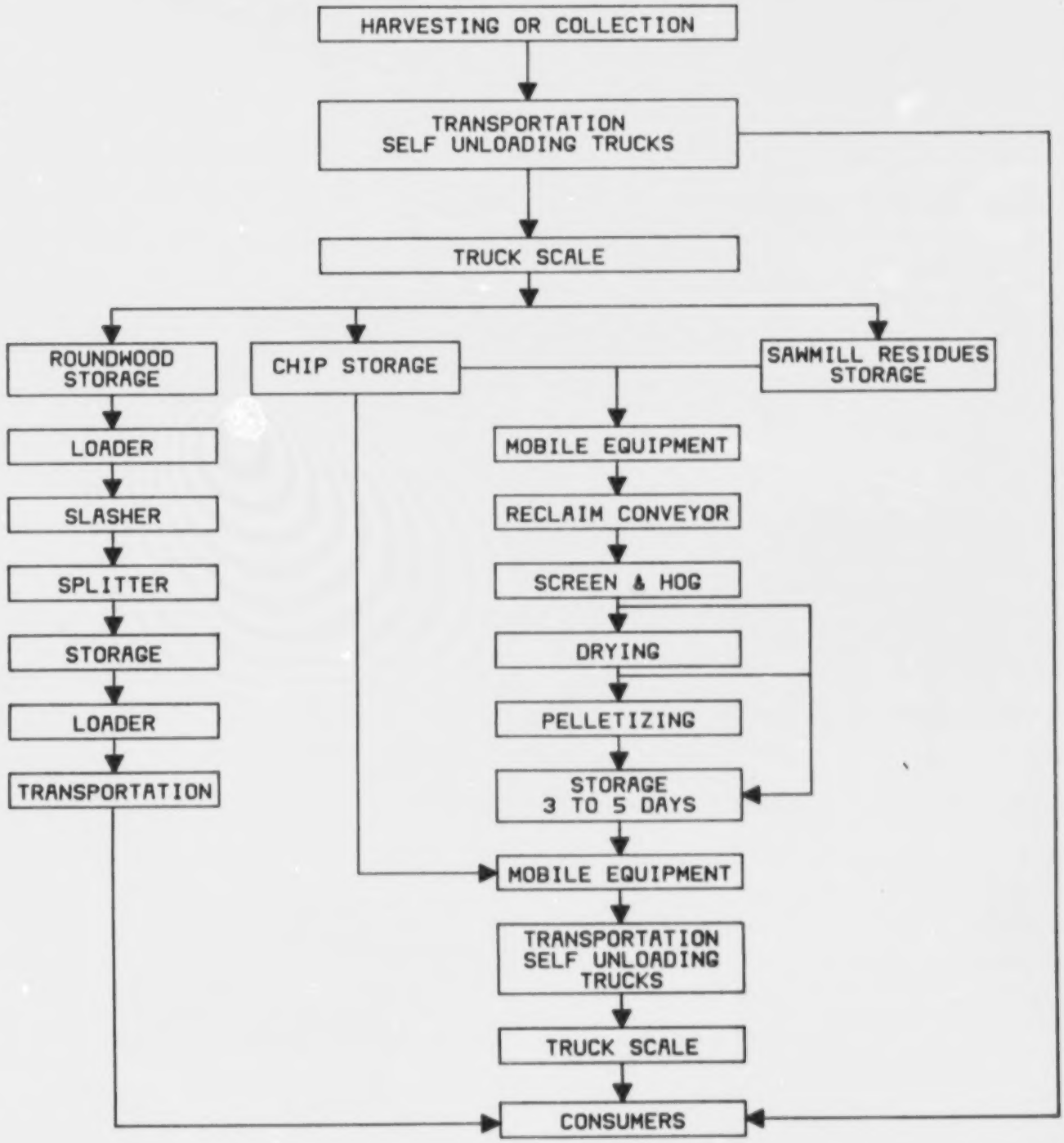
The processing components described above could be combined into a central processing system which is shown in figure 6. The raw materials from sawmills or harvesting operations would be delivered to a central depot in self unloading trucks where they would be unloaded into separate storage piles. The roundwood would be slashed into 16", 18" or 24" lengths and split shortly after receipt and piled for natural air drying. The chips and sawmill residues would be stored under tarpaulins to prevent moisture pickup from rain and snow. These materials would be processed at a steady rate to meet consumer demands. An inventory of processed material sufficient for five days of consumer demand would be provided in a covered storage shed to allow for equipment breakdowns and variations in deliveries due to poor weather conditions.

Materials could be removed from the system at any point in the flow and delivered directly to the appropriate consumers. For example, chips could be delivered directly from the harvesting operation to a major industrial consumer who is using raw chips.

FIGURE 6

FLOW CHART

CENTRAL PROCESSING SYSTEM



5.5 Inventory and Storage

An inventory of wood fuels must be maintained at several points in the wood energy system in order to overcome seasonal differences in fuel supply and demand, to permit orderly and economic deliveries from the supply to the consumer, and to ensure a reliable and adequate supply of wood fuels during unexpected problem periods. The inventory points will be at the consumer, at the fuel processing location, and at the fuel source. Each of these locations will require a fuel storage volume and method which is particular to its specific function in the system.

5.5.1 Consumer Storage

Fuel storage requirements at the consumer locations will vary with the nature of the heating plant, the type of fuel, the type of consumer, and the labour available at the consumer's location. The wood fuel should be stored in an enclosure to prevent moisture gain from rain and snow. The type and size of enclosure will depend on the consumer's requirements. For large consumers, the enclosure could be a circular silo with an automatic outfeed system from the silo to the furnace or boiler. The silo would also require a filling system from the delivery truck to the top of the silo. The silo size would depend on the frequency of deliveries but should normally hold a minimum of three days supply of fuel.

One alternative to a fixed silo is the use of a self unloading chip van as the storage and outfeed system. The wood energy supplier could deliver a fuel van, place it to discharge into a receiving conveyor and hook it up to a power supply. The "live

bottom" would start and stop automatically to keep the conveyor full. The supplier would replace the empty van with a full one as required.

For smaller consumers, the enclosure could be a rectangular bin with a set of outfeed screws from the bin to the furnace or boiler. This bin should be constructed below grade, partially below grade or above grade with a loading ramp so that it can be filled directly from a dump truck or other similar self unloading truck. The bin should be of sufficient size to receive at least one full truck load of fuel. In the case of a residential consumer providing both space and domestic hot water heating, this would be one month's supply of fuel for the peak month of January.

For agricultural consumers or others having bucket loaders, the storage system could consist of a small enclosed bin, similar to the one discussed above for small consumers, which would hold one day's supply of fuel and a semi-enclosed shed to hold one or more weeks of supply. This arrangement has the advantage of reducing storage facility costs assuming that the bucket loader and labour are at no added cost to the enterprise.

5.5.2 Central Storage

An inventory of wood fuel must be maintained at a central storage location in order to balance out variations in the supply of and demand for the fuel. The unprocessed fuel can be stored in piles on a paved surface. Paving is recommended to prevent contamination by stones and dirt. These piles can be covered with tarpaulins to reduce moisture gain from rain and snow.

However, in order to protect against excessive heat buildup and spontaneous combustion in chip and sawmill residue piles, the pile height should not exceed 15 feet; open spaces should be left in the tarpaulins and the pile sides left uncovered. Several smaller separated piles should be used instead of one large pile. Processed fuel such as hogged sawmill wastes, dried chips or pellets should be stored in weathertight enclosures. The type of enclosure used will depend on the storage volume required. For storage volumes over 200 cubic meters, a pole barn type of construction would be adequate and the most economical form of enclosure. For volumes under 200 cubic meters, elevated chip bins which can discharge directly into open top trucks may be the most suitable. These are commonly used in sawmills for this purpose.

5.5.3 Fuel Source

Some inventory of raw wood fuel can be maintained at the source of supply. This could be residues at the sawmill or logging slash and whole trees at roadside. In the case of roadside inventories of slash and trees, the usefulness of this storage is limited by the seasonal condition of the access roads. The advantage of inventories at the source is simpler storage systems and lower inventory costs.

5.6 Deliveries

Wood fuels will generally be delivered to match the consumer's demand patterns. Deliveries to large industrial consumers would be in self unloading chip vans while deliveries to smaller consumers would use dump trucks or potato trucks which could unload directly into the storage bins or enclosures. It is expected that all deliveries and billings would be made on a weight basis.

5.7 Services to Consumers

Consumers who use wood chips and wood residue fuels will require all of the services that owners of an oil fired furnace would need plus additional services that are particular to solid fuels. The regular services to non-industrial consumers generally consist of an annual furnace inspection, adjustment and cleaning as well as a maintenance insurance contract. Consumers with a wood fueled furnace could require an expansion of these services to include a twice yearly furnace and flue cleaning, maintenance insurance on the additional mechanical equipment associated with the fuel feeding system, and possibly removal of the furnace ashes from the owner's property. This latter service will depend on the consumer's location and existing municipal services. The larger industrial consumers generally provide for their own furnace or boiler maintenance and cleaning but ash disposal by the fuel supplier may be necessary.

6. Business Models

The harvesting and distribution of wood energy fuels can be accomplished through a variety of alternate business models. These models combine the various components of the wood energy industry to match the particular raw material supply and wood energy product options available in the study area. The basic models are shown in the flow diagrams contained in Appendix 3. Each of these models is described in the following sections. A financial analysis of each alternative is presented in Section 7.

6.1 Model No. 1

Wood Chip Supply Business

This business would supply green wood chips to various consumers in all sectors of the market. However, the primary emphasis would be on industrial and larger agricultural and institutional consumers and to a lesser extent on residential consumers. The business structure would consist of harvesting operations, a central depot containing a truck scale, chip storage pile, front-end loader, and business office, and chip transport vehicles.

The raw material supply will be in the form of whole tree chips from pure and residual hardwood stands and from tops and branches left at roadside after pulpwood harvesting operations. The harvesting system will consist of conventional cut and skid or forwarder operations to roadside for full tree harvesting and a standard whole tree chipper with chip screen for chipping the trees and roadside slash. The chips would be blown directly into live bottom chip vans which would travel to a central depot for weighing on a truck scale owned by the business. The vans would then either travel directly to large consumers or discharge into a storage pile at the central depot.

The chip storage pile would be required to provide an inventory to balance the seasonal differences between fuel supply and demand and to provide a trans-shipment point for deliveries to small volume consumers. The small volume deliveries would be made with a conventional dump truck. A front-end loader would be used for loading into the chip storage pile and for loading the delivery trucks.

The labour requirements for this model would consist of the harvesting and chipping crews, truck drivers, a front-end loader operator who would also operate the truck scale, and a business/office manager. For the financial model, it is assumed that the harvesting, chipping and trucking operations will be contracted. However, the business would purchase and own the specialized live bottom chip vans required for transportation. The cost of labour and the equipment operating, maintenance and depreciation costs for these operations are included in the unit costs for these functions.

6.2 Model No. 2

Sawmill Residue Supply Business

This business would supply hogged sawmill residues to various consumers in all sectors of the market. The raw material supply would consist primarily of bark and sawdust from small sawmills in the business area. The business structure would consist of a central plant containing a truck scale, bark hogging and screening equipment, front-end loader, storage pile and a business office, and transport vehicles.

Conventional dump trucks would pick up residues from the various small sawmills in the region and deliver them to the central plant where they would be weighed and then dumped into a raw material storage pile.

A front-end loader would reclaim from the raw storage pile and meter this material into the bark hogging equipment where the bark and wood pieces would be reduced to a size suitable for burning in conventional wood chip furnaces or boilers. The hogged material would be either loaded directly into delivery trucks or stored under cover in a three to five day storage pile for future deliveries. The bark hogging system would be operated only as required to match fuel deliveries to consumers and to maintain the three to five day inventory of processed material.

The labour requirements for this model would consist of the truck drivers and a plant operator who would operate the truck scale, front-end loader and bark hogging equipment, and a business/office manager. The business would operate on an 8-hour per day, 5 day per week basis. For the financial model, it is assumed that the trucking operations will be contracted. However, the business will purchase and own a large body self-dumping trailer. The trucking costs include the cost of labour; and equipment operating, maintenance and depreciation costs.

6.3 Model No. 3

Dried Wood Chip Supply Business

This business would supply wood chips, which are dried to 20% moisture content on a wet basis, to various consumers in the market. The business structure would consist of chip harvesting operations, a central plant containing a truck scale, green chip storage pile, front-end loader, mechanical chip drying system, dried chip storage enclosure and a business office, and chip transport vehicles.

Chips would be harvested, delivered to the central plant, weighed and unloaded into the green storage pile. This operation is the same as Model No. 1. The front-end loader would reclaim from the green storage pile and meter this material into the drying system where it would be hogged to reduce oversized particles and to produce fines for the dryer heating system, dried in a direct fired mechanical dryer, screened to remove fines for the dryer heating system and either loaded directly into the delivery trucks or stored in the three to five day storage enclosure. Ten percent extra raw material is required for the dryer heating system.

The labour requirements for this model would be similar to Models 1 & 2 with the addition of an operator to run the drying system. The financial analysis for this model is based on the same assumptions used in Model 1.

6.4 Model No. 4

Wood Pellet Supply Business

This business would supply densified wood pellets to various consumers in all sectors of the market. The raw material would consist of an equal mixture of wood chips and sawmill residues. The business structure would consist of the material supply operations for wood chips and sawmill residues described in Models 1 & 2 above, a central plant as described in Model 3 above with the addition of pelletizing equipment, and transportation vehicles.

The business operation would be the same as Model No. 3 and labour requirements would be increased to include an additional plant operator for the pelletizing equipment and a full-time maintenance person. The financial analysis is based on the same assumptions as the previous models. Maintenance labour is included under maintenance costs.

6.5 Model No. 5

Fuel Wood Supply Business

This business would supply fuel wood to various consumers in the market area. The main emphasis would be towards the residential sector. The business structure would consist of a conventional fuel wood system with harvesting operations, a central processing plant containing a slasher and splitter, pulpwood loader, a business office, and transportation vehicles.

Fuel wood in 8-foot lengths would be delivered to the central plant, scaled and unloaded into storage. The fuel wood would be supplied to consumers in a variety of lengths and forms. These would consist of 8-foot wood, and 24-inch, 18-inch, and 16-inch chunk wood in split and unsplit form. A material loss of 5% is assumed, based on a sales mix of 8-foot and unsplit and split chunk wood. The labour required would consist of a business/office manager and two persons to operate a loader, high volume slasher, and two splitters. In the financial analysis for this model, it is assumed that the roundwood harvesting and delivery is contracted and that the business purchases and owns a delivery truck. The operating and labour costs for the delivery truck are included in the transportation costs.

7. Financial Analysis of the Business Models

7.1 Introduction

A financial analysis of each of the five basic business models described in Section 6 was performed in order to determine the viability of the various wood energy industry alternatives. Income statements for each business model were calculated based on estimated sales volumes, sales prices, and capital, operating and overhead costs. Five-year proforma profit statements and a summary of capital costs and labour requirements for each model are contained in Appendix 4.

7.2 Assumptions

The principal assumptions used in the financial analysis of the models are described below.

(a) All costs and revenues are in 1983 dollars. Sales prices and volumes are each escalated at 7% per year and costs are escalated at 5% per year.

(b) Certain operations are performed on a contract basis. These include raw material harvesting and transportation. The costs for these contracted operations include the contractors' overhead and profit.

(c) Wage rates for the operating personnel in the models have been set at $8 per hour plus 20% for statutory payroll costs and fringe benefits.

(d) Depreciation is calculated on a double declining balance basis An average asset life of 10 years has been assumed for buildings, equipment and mobile equipment.

(e) Interest charges of 12% per year are applied to bank loans for capital borrowing and inventory costs.

(f) Equity invested in the business is 25% of the total assets.

(g) Cash flow at year end is used to reduce bank loans in the year following.

(h) Tax rates of 24% on the first $250,000 of taxable income and 50.9% on the balance are used.

7.3 Financial Viability

Three financial scenarios were prepared for each business model. These scenarios are termed Pessimistic Case, Probable Case and Optimistic Case and are based on varying sales prices as discussed in Section 7.3.1 below. The results of the financial analysis for each business model are summarized in Tables 15 to 17 below. In the Pessimistic Case analysis only the Sawmill Residue Supply Business has an attractive return on investment while in the Probable and Optimistic Case analysis the Wood Chip, Sawmill Residue and Fuel Wood Supply Businesses have attractive returns on investment. The primary factors which affect the profitability of the business models are discussed below.

7.3.1 Sales Prices and Volumes

Each business model is sensitive to the prices received for the wood energy fuel and to the volume of sales. The Pessimistic Case financial analysis uses the arithmetic average of the sales prices which are shown in Section 3. These sales prices were strongly influenced by conservative cost estimates for the installed costs of the wood energy heating plants. For the Optimistic Case analysis, the sales prices were recalculated with the following changes.

(a) The 15% contingency allowance used in the original installed cost estimates was deleted. This is justified on the basis that many of the consumers would make the maximum use of available used equipment and would also use their own labour for the installations.

(b) The target return on investment for the heating plant installations was lowered from 20% to 15%.

(c) For residential consumers, the COSP grant of 50% of the installed cost, up to a maximum of $800, was included in the calculations.

The Probable Case uses a sales price midway between the Pessimistic and Optimistic Cases. A summary of the sales prices is shown in table 14 below. In addition, for each model and case, a sales price and a sales volume which will yield a 20% after tax discounted cash flow return on investment for the business is calculated. These prices and volumes are shown in Table 15 to 17.

Table 14

Wood Fuel Sales Price Limits
$/bone dry tonne

	Chips 50% M.C.	Chips 20% M.C.	Pellets 10% M.C.	Fuel Wood 30% M.C.
Pessimistic Case	43.00	51.00	69.00	61.00
Probable Case	55.00	65.00	82.00	74.00
Optimistic Case	67.00	80.00	95.00	88.00

Note: These sales prices are based on the arithmetic average of the estimated sales prices calculated in the seven cases contained in Appendix 1.

7.3.2 Material Supply, Transport and Handling Costs

The purchasing, transporting and handling of the wood energy fuel are the major cost factors in all of the business models. In the most profitable models, Models 2 & 4, these costs make up about 50% of the total operating costs, while in the less attractive cases, they range from 62% to 86% of total costs. These costs are also the least controllable of all the factors. Wood chip and roundwood harvesting and transportation costs are well defined by the businesses currently operating in the province.

7.3.3 Overhead Costs

Some components of the overhead costs which are required to operate and manage the business can be controlled or changed to a limited extent. The controllable components are the salaries and wages for administration and operating labour, and miscellaneous expenses such as telephone, maintenance and power. The easiest components to control are salaries and wages. Lower wage rates and seasonal or part-time labour could be used to reduce overhead costs. A more likely option would be for an existing pulpwood chipping contractor to enter the wood energy business utilizing and sharing his present overhead staff and facilities.

7.3.4 Interest Costs

Interest payments are primarily affected by the loans for capital investment and, to a lesser extent, by inventory and other working capital costs. The capital cost of the business can be reduced by the purchase of used equipment, by integrating the business with an existing related business, or by a combination of these. Other interest costs could be controlled to a limited extent through the management of accounts receivable and accounts payable with the primary method being for the raw material suppliers to receive delayed or partial payments for their deliveries and for the customers to pay for the fuel on delivery.

7.4 Summary

The Probable Case financial analysis of the various business models indicates that the Wood Chip, Sawmill Residue and Fuel Wood Supply businesses are financially viable. The Sawmill Residue Supply Business, in the Pessimistic Case and Probable Case analysis, has the highest return on investment of the various models because of the low cost for the raw materials used by this business.

Each model is extremely sensitive to changes in sales prices as shown by the substantial increase in return on investment from the Pessimistic Case to the Probable Case. This is especially true for the Wood Chip and Fuel Wood Supply Businesses. However, there is a good margin of safety between the Probable Case sales prices and the minimum sales prices required to produce a 20% return on investment. The sales prices for wood chips, sawmill residues and fuelwood could drop by 18%, 50% and

17% respectively and still give an attractive return on investment. The models are much less sensitive to changes in sales volumes. In the Probable Case analysis, wood chip, sawmill residue, and fuel wood sales could decrease by 54%, 64% and 48% respectively and still yield a 20% return on investment.

The business models are also affected by capital costs. New equipment prices were used in estimating the capital costs of the businesses and government incentives to businesses were not included in the analysis. The business profits and returns on investment would be increased if used equipment and/or government business incentives were obtained.

Table 15

Summary of First Year Financial Statements for Business Models

PESSIMISTIC CASE

	MODEL				
	1 Wood Chips	2 Sawmill Residues	3 Dried Chips	4 Pellets	5 Fuel Wood
Sales Volume (BDT/yr.)	15,850	15,850	15,850	15,850	8,400
Sales Price ($/BDT)	43	43	51	69	61
Taxable Income	-86,380	201,405	-470,056	-351,148	-47,172
Taxes	0	48,337	0	0	0
Net Profit	-86,380	153,068	-470,056	-351,148	-47,172
5 Year DCFROI	8.4%	52.7%	NEG	8.6%	18.8%
Sales Price ($/BDT) to Yeild 20% DCFROI	45.00	27.49	74.83	86.26	61.22
Sales Volume (BDT/yr.) to Yeild 20% DCFROI	20,600	7,950	50,420	22,250	8,540

Table 16

Summary of First Year Financial Statements for Business Models

PROBABLE CASE

	MODEL				
	1 Wood Chips	2 Sawmill Residues	3 Dried Chips	4 Pellets	5 Fuel Wood
Sales Volume (BDT/yr.)	15,850	15,850	15,850	15,850	8,400
Sales Price ($/BDT)	55	55	65	82	74
Taxable Income	103,821	391,605	-248,156	-145,098	62,028
Taxes	24,917	132,077	0	0	14,887
Net Profit	78,904	259,528	-248,156	-145,098	47,141
5 Year DCFROI	65.4%	71.2%	8.9%	17.3%	77.7%
Sales Price ($/BDT) to Yeild 20% DCFROI	45.00	27.49	74.83	86.26	61.22
Sales Volume (BDT/yr.) to Yeild 20% DCFROI	7,350	5,730	22,100	17,060	4,340

Table 17

Summary of First Year Financial Statements for Business Models

OPTIMISTIC CASE

	MODEL				
	1 Wood Chips	2 Sawmill Residues	3 Dried Chips	4 Pellets	5 Fuel Wood
Sales Volume (BDT/yr.)	15,850	15,850	15,850	15,850	8,400
Sales Price ($/BDT)	67	67	80	95	88
Taxable Income	294,021	581,805	-10,406	60,952	179,628
Taxes	82,406	228,889	0	14,628	43,111
Net Profit	211,614	352,916	-10,406	46,323	136,517
5 Year DCFROI	103.5%	88.0%	25.0%	24.8%	131.0%
Sales Price ($/BDT) to Yeild 20% DCFROI	45.00	27.49	74.83	86.26	61.22
Sales Volume (BDT/yr.) to Yeild 20% DCFROI	4,480	4,485	13,800	13,840	2,840

8. Business Skills, Type and Location

This section reviews the type and source of business and labour skills required for the industry, the factors affecting the location of the business and the advantages of a business integrated with an existing wood related enterprise.

8.1 Business and Labour Skills

The wood energy industry would require skilled and semi-skilled personnel for its successful operation. These personnel are presently available or the training facilities and programs necessary to create the skills are in place. The specific skill requirements of each component of the industry are discussed below.

(a) Harvesting

Harvesting and processing of forest products is one of the major industries in the Province of New Brunswick. The existing industry employs thousands of skilled forest workers. There are established training programs for the development of these skilled personnel. The harvesting component of the wood energy industry would use the same equipment and skills used in sawlog and pulpwood harvesting. Therefore the industry would not encounter any difficulties in obtaining the necessary skills for the harvesting of forest biomass.

(b) Transportation and Delivery

The transportation of forest products in all forms is an equally well established industry in New Brunswick. The wood energy industry will have no problems in obtaining the personnel and equipment necessary to transport and deliver both its raw materials and finished products.

(c) Processing

The various processing alternatives for wood energy fuels would utilize relatively conventional equipment and skills for their operation and maintenance. Some specialized on-the-job training would be required during the start-up phase of some of the business models, but once again the basic skills and resources are available.

(d) Services to Users

The non-industrial consumers of wood energy fuels would require the services of furnace maintenance mechanics. The basic skills and resources for this service are the oil burner mechanics who currently service the traditional oil fired furnaces. It is suggested that the skills of these personnel be upgraded to include specific training in the installation and servicing of solid fuel combustion systems. This training should include:

- Wood combustion theory.
- The effect of moisture content and combustion air on furnace performance and creosote formation.
- Flue inspection and maintenance.
- The additional fire hazards associated with solid fuel combustion and storage systems.

The New Brunswick Community College and the Department of Labour and Manpower currently provide training and certification respectively of oil burner mechanics and could easily expand their existing programs to include solid fuel combustion training and certification.

(e) Business Management

The business skills necessary to operate the wood energy industry are similar to those required for any small business. In addition the business management personnel would require a thorough knowledge of the various operating components of the wood energy industry. These business skills and industry knowledge are particularly similar to the skills employed by sawlog and pulpwood harvesting contractors and sawmill operators.

8.2 Type of Business

The wood energy industry could be established as an independent business or as an addition to an existing wood related enterprise. The latter case is more attractive for several reasons. Adding a wood energy business to an existing wood related enterprise offers savings in overhead costs and through the sharing and increased utilization of existing manpower and equipment. This is especially true if the new business is initiated by an existing independent wood chip harvesting contractor since in most cases they are operating at less than full capacity due to quota limits established by the pulp mills that are purchasing their chips. In addition, an integrated business would assure a more reliable supply of raw materials and transportation equipment.

8.3 Business Location

The locations from which a wood energy industry could operate would depend on the locations of the major consumers and the supply of raw materials. The location of the central depot or processing plant should be chosen to minimize overall transportation distances.

9. References

1. Energy Secretariat, Province of New Brunswick, New Brunswick Energy Review, 1982.
2. Statistics Canada, 1981 Census of Canada, Cat. 93-904, Vol. 2.
3. New Brunswick Electric Power Commission, Mr. N. Bhutani.
4. Department of Commerce and Development, Province of New Brunswick, Directory of Products and Manufacturers, 1982.
5. T.I.S. Business Directory, Saint John - Sussex, 1982-1983.
6. Saint John Fundy Region Development Commission, Community Profile.
7. Department of Agriculture, Province of New Brunswick.
8. Department of Commerce and Development, Province of New Brunswick, Wood Residue Survey, 1980.
9. Department of Natural Resources, Province of New Brunswick, New Brunswick Forest Inventory - 1981.
10. W. Torunski, J.D. Irving Ltd. Personal communications.
11. G. van Raalte, 1983, Maritime Forest Research Centre, CFS, personal communication.
12. Savage G.D. and E.J. O'Hara, 1981. Salvaging logging residues for fuel chip production. Thesis - University New Brunswick, Fredericton, New Brunswick.
13. Cogeneration Associates Ltd, Assessment of the Institutional and Market Constraints Associated with Biomass Energy by Small to Medium Industrial - Commercial Users, Energy, Mines and Resources, Ottawa, October 1981.
14. Middleton Associates, Biomass Energy in Canada, Its Potential Contribution to Future Energy Supply, Energy, Mines and Resources, Ottawa. (ER 80-4E), March 1980.

15. J. Hermelin, M. H. Schneider, C. A. Short, Wood Chip Heating of Homes and Other Small Buildings, Jan. 1982.

16. B. H. Levelton & Associates, An Evaluation of Wood Waste Energy Conservation Systems - 1980, ENFOR Report C-111, March, 1981.

Appendix 1

Fuel Demand Data

Appendix 1

Table 1.1

Fuel Oil Consumption

Industrial

	Annual Consumption	
	Oil (litres)	Wood Equivalent (bone dry tonnes)
A	2,325,000	6,000
B	300,000	774
C	681,000	1,758
D	38,000	98
E	426,000	1,100
F	366,935	947
G	N/A	-----
H	4,218,000	10,888
I	10,364,000	26,752
J	12,000	31
K	N/A	-----
L	N/A	-----
M	10,896,000	28,126
N		888
Total	29,970,935	77,362

Appendix 1

Table 1.2

Fuel Oil Consumption

Agricultural

	Annual Consumption	
	Oil (litres)	Wood Equivalent (bone dry tonnes)
A	54,500	141
B	113,500	293
C	79,450	205
D	36,320	94
E	681,000	1,758
Total	964,770	2,491

Appendix 1

Table 1.3

Fuel Oil Consumption

Institutional

	Annual Consumption	
	Oil (litres)	Wood Equivalent (bone dry tonnes)
Schools		
District 16: (Havelock only)		
Total 1981-82	55,547	143
Major Consumers none		
District 18:		
Total 1981-82	560,526	1,447
Major Consumers:		
Sussex Regional High	198,134	511
Sussex Junior High	245,394	633
Norton Elementary 52,199	115	
District 19:		
Total 1981-82	717,484	1,852
Major Consumers:		
Kennebecasis Valley High	342,280	883
Rothesay Junior High	115,181	297
Belle Isle Regional High	61,582	159
Harry Miller Jr. High	58,767	152
Rothesay Park Elementary	51,873	134
Note: New Belleisle School - estimated 300 Tons/yr wood chips.		
District 24:		
Total 1981-82	385,498	995
Major Consumers:		
Minto Memorial	104,479	270
Chipman High	81,722	211
Parker Memorial	68,825	178
Total (all districts)	1,719,055	4,437

Source: Department of Education, Province of New Brunswick.

Appendix 1

Table 1.4

Fuel Oil Consumption

Institutional

	Annual Consumption	
	Oil (litres)	Wood Equivalent (bone dry tonnes)
Health Services		
Sussex Medical Health	N/A	-
Kiwanis Nursing Home Inc.	110,000	284
Mill Cove Nursing Home	57,600	149
Eastern Star Home	N/A	-
Anglican Church Home	N/A	-
Total	167,600	433

Appendix 1

Table 1.5

Fuel Oil Consumption

Institutional

	Annual Consumption	
	Oil (litres)	Wood Equivalent (bone dry tonnes)
Public Buildings		
Town of Sussex	DATA NOT AVAILABLE	
Sussex Armory		
N.B. Provincial Building - Sussex		
Kings County Court House		
Kings County Memorial Stadium		
Post Office, Sussex		
Dept. of Supply & Services, Hampton		
Dept. of Transportation		
- Sussex District	313,564	809
- Largest Facility: Sussex	(150,000)	(387)
- Chipman District	180,214	465
- Largest Facility: Chipman	(68,000)	(175)
Total	493,778	1,274

Appendix 1

Determination of Wood Fuel Sales Price Limits

Seven typical consumers in the study area were examined to determine the installed cost, operating cost, and fuel consumption for wood fueled heating plants. The wood fuel sales prices are determined by calculating the wood fuel cost which will bring the sum of the present values of the savings minus the expenses to zero using an interest rate of 15% or 20% and a life of 10 years. The principal assumptions used in the seven cases are:

(a) All costs are in 1983 dollars with no escalation.

(b) Interest charges on capital borrowings are excluded.

(c) A tax rate of 50% is used in all non-residential cases and taxes were excluded from the residential cases.

(d) A FIRE grant equal to 18% of the plant cost is used for non-residential cases.

Note: Where the title "chips" is used it includes both wood chips and sawmill residues.

Appendix 1

Case I: Industrial

1. Description

Industrial plant operating eight hours per day, seven days per week, 52 weeks per year using oil fired boilers to produce steam for process and building heat. The process steam demand is relatively constant through out the year. The existing oil fired boilers are attended during the day shift only.

2. Assumptions

A new wood fuel boiler is installed using hogged bark and wood chips to supply the dayshift steam demand with the off-hours steam being supplied by the existing oil fired boilers. The existing operator attends the new installation with no increase in labor costs.

DETERMINATION OF WOOD FUEL SALES PRICE LIMITS

CASE 1: INDUSTRIAL, PESSIMISTIC CASE

NGL JOB 3871
3871case1m
83-06-28

INPUT DATA & BASIC ASSUMPTIONS

1. Plant cost		9. FIPE Grant $			CASE 1a	CASE 1b	CASE 1c
1a	193000	1a	34740	17. % oil combus	.8	.8	.8
1b	193000	1b	34740				
1c	143000	1c	25740				
2. Plant size (MJ/hr)	3160	10. Net plant cost ($)		18. Heat content oil (J/l)	38700000	38700000	38700000
		1a	158260				
		1b	158260				
3. Existing oil use/year (l)	300000	1c	117260	19. % wood subs	.9	.9	.9
		11. Required IRR	.2	20. Heat content wood (J/t)	20000000000	20000000000	20000000000
4. $/l oil	.32	12. # yrs plant life (n)	10				
5. Current oil costs ($/yr)	96000	13. Plant salvage value @ n yrs,% & $	40	21. % wood combustion@% H2o	.6	.71	.73
6. Extra labour costs ($/yr)	0	1a	77200	22. %H20 in wood	.5	.2	.1
		1b	77200				
		1c	57200				
7. % Mtnc costs	2	14. PVIF(a:IRR n	4.192472080	23. Wood fuel required (bdt/yr)	696.60	588.68	572.55
7.1 Extra maintenance costs ($/yr)		15. NPV/yr n.IRR	.1615055829				
1a	3860						
1b	3860						
1c	2860	16. Tax rate	.5				
8. % oil use	10		.5				
8.1 Future oil use ($/yr)	9600						

Calculate maximum cost of wood fuel ; given above criteria

	CASE 1a WET CHIPS		CASE 1b DRY CHIPS		CASE 1c PELLETS	
	Debit	Credit	Debit	Credit	Debit	Credit
1.Plant cost	158260.00		158260.00		117260.00	
2.Fuel saving		181114.79		181114.79		181114.79
3.P.V. maintenance	8091.47		8091.47		5995.24	
4.P.V. CCA		39565.00		39565.00		29315.00
5.P.V. salvage		12468.23		12468.23		9238.12
6.P.V. loss on salvage CCA	3117.06		3117.06		2309.53	
7.P.V. extra labour	0		0		0	
	169468.53	233148.03	169468.53	233148.03	125564.76	219667.91
Maximum price / bdt of wood fuel delivered =		43.61		51.60		78.41

DETERMINATION OF WOOD FUEL SALES PRICE LIMITS

CASE 1: INDUSTRIAL, OPTIMISTIC CASE

NGL job 3071
3071case1b
83-06-28

INPUT DATA & BASIC ASSUMPTIONS

1. Plant cost		9. FIRE Grant $			CASE 1a	CASE 1b	CASE 1c
1a	167400	1a	30132	17. % oil combus	.8	.8	.8
1b	167400	1b	30132				
1c	124200	1c	22356				
2. Plant size (MJ/hr)	3160	10. Net plant cost ($)		18. Heat content oil (J/l)	38700000	38700000	38700000
		1a	137268				
		1b	137268				
3. Existing oil use/year (l)	300000	1c	101844	19. % wood subs	.3	.3	.3
		11. Required IPP	.15				
4. $/l oil	.32	12. # yrs plant life (n)	10	20. Heat content wood (J/t)	20000000000	20000000000	20000000000
5. Current oil costs ($/yr)	96000			21. % wood combustion@% H2o	.6	.71	.73
		13. Plant salvage value @ n yrs,% & $	40				
6. Extra labour costs ($/yr)	0	1a	66960	22. %H2O in wood	.5	.2	.1
		1b	66960				
		1c	49680				
7. % Mtnc costs	2	14. PVIF a,IPP n	5.018768627	23. Wood fuel required (bdt/yr)	636.60	588.68	572.55
7.1 Extra maintenance costs ($/yr)		15. NPV/yr n,IPP	.247184706				
1a	3348						
1b	3348						
1c	2484	16. Tax rate	.5				
8. % oil use	10		.5				
8.1 Future oil use ($/yr)	9600						

Calculate maximum cost of wood fuel : given above criteria

	CASE 1a WET CHIPS		CASE 1b DRY CHIPS		CASE 1c PELLETS	
	Debit	Credit	Debit	Credit	Debit	Credit
1.Plant cost	137268.00		137268.00		101844.00	
2.Fuel saving		216810.80		216810.80		216810.80
3.P.V. maintenance	8401.42		8401.42		6233.31	
4.P.V. CCA		39219.43		39219.43		29098.29
5.P.V. salvage		16551.49		16551.49		12280.14
6.P.V. loss on salvage CCA	4729.00		4729.00		3508.61	
7.P.V. extra labour	0		0		0	
	150398.42	272581.72	150398.42	272581.72	111585.92	258189.23
Maximum price / bdt of wood fuel delivered =		69.90		82.71		102.04

APPENDIX I

Case II: Industrial

1. Description

Industrial plant operating 24 hours per day, seven days per week, 50 weeks per year using oil fired boilers to produce medium pressure process steam. The steam demand is constant throughout the year and the boilers are attended during the day shift only.

2. Assumptions

A new wood fuel fired boiler is installed using hogged bark and wood chips to supply the steam demand. Additional operators must be added for the 4:00 pm to 12:00 pm and 12:00 pm to 8:00 am shifts.

DETERMINATION OF WOOD FUEL SALES PRICE LIMITS

NGL JOB 3071
3071CASE2w
83-06-28

CASE 2: INDUSTRIAL, PESSIMISTIC CASE

INPUT DATA & BASIC ASSUMPTIONS

1. Plant cost		9. FIRE Grant $			CASE 2a	CASE 2b	CASE 2c
2a	213000	2a	38340	17. % oil combus	.8	.8	.8
2b	213000	2b	38340				
2c	163500	2c	29430				
2. Plant size (MJ/hr)	3160	10. Net plant cost ($)		18. Heat content oil (j/l)	38700000	38700000	38700000
		2a	174660				
		2b	174660				
3. Existing oil use/year (l)	681000	2c	134070	19. % wood subs	.95	.95	.95
		11. Required IPP	.2				
4. $/l oil	.32	12. # yrs plant life (n)	10	20. Heat content wood (j/t)	20000000000	20000000000	20000000000
5. Current oil costs ($/yr)	217920			21. % wood combustion@% H2o	.6	.71	.73
		13. Plant salvage value @ n yrs,% & $	40				
6. Extra labour costs ($/yr)	37480	2a	85200	22. %H20 in wood	.5	.2	.1
		2b	85200				
		2c	65400				
7. % Mtnc costs	2	14. PVIF(a)IPP n	4.192472086	23. Wood fuel required (bdt/yr)	1669.13	1410.53	1371.89
7.1 Extra maintenance costs ($/yr)		15. NPV,yr n,IPP	.1615055829				
2a	4260						
2b	4260						
2c	3270	16. Tax rate	.5				
8. % oil use	5		.5				
8.1 Future oil use ($/yr)	10896						

Calculate maximum cost of wood fuel ; given above criteria

	CASE 2a WET CHIPS		CASE 2b DRY CHIPS		CASE 2c PELLETS	
	Debit	Credit	Debit	Credit	Debit	Credit
1.Plant cost	174660.00		174660.00		134070.00	
2.Fuel saving		433971.17		433971.17		433971.17
3.P.V. maintenance	8929.97		8929.97		6854.69	
4.P.V. CCA		43665.00		43665.00		33517.50
5.P.V. salvage		13760.28		13760.28		10562.47
6.P.V. loss on salvage CCA	3440.07		3440.07		2640.62	
7.P.V. extra labour	78566.93		78566.93		78566.93	
	265596.96	491396.45	265596.96	491396.45	222132.24	478051.14
Maximum price / bdt of wood fuel delivered =		64.53		76.37		88.99

DETERMINATION OF WOOD FUEL SALES PRICE LIMITS

CASE 2: INDUSTRIAL, OPTIMISTIC CASE

NGL JOB 3071
3071case2b
83-06-28

INPUT DATA & BASIC ASSUMPTIONS

1. Plant cost		
2a	185400	
2b	185400	
2c	142200	
2. Plant size (MJ/hr)	3160	
3. Existing oil use/year (l)	681000	
4. $/l oil	.32	
5. Current oil costs ($/yr)	217920	
6. Extra labour costs ($/yr)	37480	
7. % Mtnc costs	2	
7.1 Extra maintenance costs ($/yr)		
2a	3708	
2b	3708	
2c	2844	
8. % oil use	5	
8.1 Future oil use ($/yr)	10896	
9. FIRE Grant $		
2a	33372	
2b	33372	
2c	25596	
10. Net plant cost ($)		
2a	152028	
2b	152028	
2c	116604	
11. Required IRR	.15	
12. # yrs plant life (n)	10	
13. Plant salvage value @ n yrs,% & $	40	
2a	74160	
2b	74160	
2c	56880	
14. PVIF(a)IRR n	5.018768627	
15. NPV,yr n,IRR	.2471847061	
16. Tax rate	.5	.5

	CASE 2a	CASE 2b	CASE 2c
17. % oil combus	.8	.8	.8
18. Heat content oil (J/l)	38700000	38700000	38700000
19. % wood subs	.95	.95	.95
20. Heat content wood (J/t)	20000000000	20000000000	20000000000
21. % wood combustion@% H2o	.6	.71	.73
22. %H2O in wood	.5	.2	.1
23. Wood fuel required (bdt/yr)	1669.13	1410.53	1371.89

Calculate maximum cost of wood fuel ; given above criteria

	CASE 2a WET CHIPS Debit	Credit	CASE 2b DRY CHIPS Debit	Credit	CASE 2c PELLETS Debit	Credit
1.Plant cost	152028.00		152028.00		116604.00	
2.Fuel saving		519502.78		519502.78		519502.78
3.P.V. maintenance	9304.80		9304.80		7136.69	
4.P.V. CCA		43436.57		43436.57		33315.43
5.P.V. salvage		18331.22		18331.22		14059.87
6.P.V. loss on salvage CCA	5237.49		5237.49		4017.10	
7.P.V. extra labour	94051.72		94051.72		94051.72	
	260622.01	581270.57	260622.01	581270.57	221809.52	566878.07
Maximum price / bdt of wood fuel delivered =		76.55		90.59		100.23

APPENDIX I

Case III: Residential

1. Description

Private residence with oil fired hot water furnace with domestic hot water coil.

2. Assumptions

A new hogged bark and wood chip fired furnace is added.

DETERMINATION OF WOOD FUEL SALES PRICE LIMITS

CASE 3: RESIDENTIAL, PESSIMISTIC CASE

NGL JOB 3071
3071case3m
83-06-28

INPUT DATA & BASIC ASSUMPTIONS

1. Plant cost		
3a	4000	
3b	4000	
3c	3500	
2. Plant size (MJ/hr)	150	
3. Existing oil use/year (l)	4000	
4. $/l oil	.34	
5. Current oil costs ($/yr)	1360	
6. Extra labour costs ($/yr)	0	
7. % Mtnc costs	2	
7.1 Extra maintenance costs ($/yr)		
3a	80	
3b	80	
3c	70	
8. % other energy use	10	
8.1 Cost ($/yr)	136	
9. COSP Grant $		
3a	0	
3b	0	
3c	0	
10. Net plant cost ($)		
3a	4000	
3b	4000	
3c	3500	
11. Required IRR	.2	
12. # yrs plant life (n)	10	
13. Plant salvage value @ n yrs,% & $		
3a	0	
3b	0	
3c	0	
14. PVIF(a)IRR n 4.192472086		
15. NPV,yr n,IRR .1615055829		
16. Tax rate	0	

	CASE 3a	CASE 3b	CASE 3c
17. % oil combus	.8	.8	.8
18. Heat content oil (J/l)	38700000	38700000	38700000
19. % wood subs	.9	.9	.9
20. Heat content wood (J/t)	20000000000	20000000000	20000000000
21. % wood combustion@% H2o	.6	.71	.73
22. %H20 in wood	.5	.2	.1
23. Wood fuel required (bdt/yr)	9.29	7.85	7.63

Calculate maximum cost of wood fuel : given above criteria

	CASE 3a WET CHIPS Debit	CASE 3a WET CHIPS Credit	CASE 3b DRY CHIPS Debit	CASE 3b DRY CHIPS Credit	CASE 3c PELLETS Debit	CASE 3c PELLETS Credit
1.Plant cost	4000.00		4000.00		3500.00	
2.Fuel saving		5131.59		5131.59		5131.59
3.P.V. maintenance	335.40		335.40		293.47	
4.P.V. CCA		0.00		0.00		0.00
5.P.V. salvage		0.00		0.00		0.00
6.P.V. loss on salvage CCA	0.00		0.00		0.00	
7.P.V. extra labour	0.00		0.00		0.00	
	4335.40	5131.59	4335.40	5131.59	3793.47	5131.59
Maximum price / bdt of wood fuel delivered =		20.45		24.20		41.81

DETERMINATION OF WOOD FUEL SALES PRICE LIMITS

CASE 3: RESIDENTIAL, OPTIMISTIC CASE

NGL JOB 3071
3071case3b
83-06-28

INPUT DATA & BASIC ASSUMPTIONS

1. Plant cost		9. COSP Grant $			CASE 3a	CASE 3b	CASE 3c
3a	3500	3a	800	17. % oil combus	.8	.8	.8
3b	3500	3b	800				
3c	3000	3c	800				
2. Plant size		10. Net plant cost ($)		18. Heat content oil (J/l)	38700000	38700000	38700000
		3a	2700				
		3b	2700				
3. Existing oil use (m3/yr)	4000	3c	2200	19. % wood subs	.9	.9	.9
		11. Required IRR	.15				
4. $/l oil	.34	12. # yrs plant life (n)	10	20. Heat content wood (J/t)	20000000000	20000000000	20000000000
5. Current oil costs ($/yr)	1360	13. Plant salvage value @ n yrs,% & $		21. % wood combustion@% H2o	.6	.71	.73
6. Extra labour costs ($/yr)	0	3a	0	22. %H20 in wood	.5	.2	.1
		3b	0				
		3c	0				
7. % Mtnc costs	2	14. PVIF(a)IRR n 5.018768627		23. Wood fuel required (bdt/yr)	9.29	7.85	7.63
7.1 Extra maintenance costs ($/yr		15. NPV,yr n,IRR .2471847061					
3a	70						
3b	70						
3c	60						
8. % other energy use	10	16. Tax rate	0				
8.1 Cost ($/yr)	136						

Calculate maximum cost of wood fuel ; given above criteria

	CASE 3a WET CHIPS		CASE 3b DRY CHIPS		CASE 3c PELLETS	
	Debit	Credit	Debit	Credit	Debit	Credit
1.Plant cost	2700.00		2700.00		2200.00	
2.Fuel saving		6142.97		6142.97		6142.97
3.P.V. maintenance	351.31		351.31		301.13	
4.P.V. CCA		0.00		0.00		0.00
5.P.V. salvage		0.00		0.00		0.00
6.P.V. loss on salvage CCA	0.00		0.00		0.00	
7.P.V. extra labour	0.00		0.00		0.00	
	3051.31	6142.97	3051.31	6142.97	2501.13	6142.97
Maximum price / bdt of wood fuel delivered =		66.32		78.48		95.05

APPENDIX I

Case IV: Residential

1. Description

   Private residence with oil fired hot water furnace with domestic hot water coil.

2. Assumptions

   A new wood fired furnace is added to burn air dried chunk wood at 30% moisture content.

DETERMINATION OF WOOD FUEL SALES PRICE LIMITS

CASE 4: RESIDENTIAL, PESSIMISTIC CASE

NGL JOB 3071
3071case4m
83-06-28

INPUT DATA & BASIC ASSUMPTIONS

		CASE 4a
1.	Plant cost	
	4a	2500
	4b	0
	4c	0
2.	Plant size (MJ/hr)	150
3.	Existing oil use/year (l)	4000
4.	$/l oil	.34
5.	Current oil costs ($/yr)	1360
6.	Extra labour costs ($/yr)	0
7.	% Mtnc costs	2
7.1	Extra maintenance costs ($/yr)	
	4a	50
	4b	0
	4c	0
8.	% other energy use	10
8.1	Cost ($/yr)	136
9.	COSP Grant $	
	4a	0
	4b	0
	4c	0
10.	Net plant cost ($)	
	4a	2500
	4b	0
	4c	0
11.	Required IRR	.2
12.	# yrs plant life (n)	10
13.	Plant salvage value @ n yrs,% & $	0
	4a	0
	4b	0
	4c	0
14.	PVIF a;IRR n	4.192472086
15.	NPV,yr n,IRR	.1615055829
16.	Tax rate	0
17.	% oil combus	.8
18.	Heat content oil (j/l)	38700000
19.	% wood subs	.9
20.	Heat content wood (j/t)	20000000000
21.	% wood combustion@% H2o	.6
22.	%H20 in wood	.3
23.	Wood fuel required (bdt/yr)	9.29

Calculate maximum cost of wood fuel : given above criteria

	CASE 4a Debit	ROUND WOOD Credit
1.Plant cost	2500.00	
2.Fuel saving		5131.59
3.P.V. maintenance	209.62	
4.P.V. CCA		0.00
5.P.V. salvage		0.00
6.P.V. loss on salvage CCA	0.00	
7.P.V. extra labour	0.00	
	2709.62	5131.59

Maximum price / bdt of wood fuel delivered = 62.20

DETERMINATION OF WOOD FUEL SALES PRICE LIMITS

NGL JOB 3071
3071case4b
83-06-28

CASE 4: RESIDENTIAL, OPTIMISTIC CASE

INPUT DATA & BASIC ASSUMPTIONS

					CASE 4a
1. Plant cost		9. COSP Grant $		17. % oil combus	.8
4a	2500	4a	800		
4b	0	4b	0		
4c	0	4c	0		
2. Plant size (MJ/hr)	150	10. Net plant cost ($)		18. Heat content oil (J/l)	38700000
		4a	1700		
		4b	0		
3. Existing oil use/year (l)	4000	4c	0	19. % wood subs	.9
		11. Required IRR	.15		
4. $/l oil	.34	12. # yrs plant life (n)	10	20. Heat content wood (J/t)	20000000000
5. Current oil costs ($/yr)	1360			21. % wood combustion@% H2o	.6
		13. Plant salvage value @ n yrs.% & $	0		
6. Extra labour costs ($/yr)	0			22. %H20 in wood	.3
		4a	0		
		4b	0		
		4c	0		
7. % Mtnc costs	2	14. PVIF(a)IRR n	5.018768627	23. Wood fuel required (bdt/yr)	9.29
7.1 Extra maintenance costs ($/yr)		15. NPV.yr n.IRR	.2471847061		
4a	50				
4b	0				
4c	0				
8. % other energy use	10	16. Tax rate	0		
8.1 Cost ($/yr)	136				

Calculate maximum cost of wood fuel ; given above criteria

	CASE 4a Debit	ROUND WOOD Credit
1.Plant cost	1700.00	
2.Fuel saving		6142.97
3.P.V. maintenance	250.94	
4.P.V. CCA		0.00
5.P.V. salvage		0.00
6.P.V. loss on salvage CCA	0.00	
7.P.V. extra labour	0.00	
	1950.94	6142.97

Maximum price / bdt of wood fuel delivered = 89.93

APPENDIX I

Case V: Residential

1. Description

Private residence with electric or oil fired space heating.

2. Assumptions

Install small air tight chunk wood stove to supply 75% of space heating needs. Compare to oil heating.

DETERMINATION OF WOOD FUEL SALES PRICE LIMITS

CASE 5: RESIDENTIAL, PESSIMISTIC CASE

NGL JOB 3071
3071case5w
83-06-28

INPUT DATA & BASIC ASSUMPTIONS

		CASE 5a
1.	Plant cost	
	5a	1200
	5b	0
	5c	0
2.	Plant size (MJ/hr)	50
3.	Existing oil use/year (l)	2700
4.	$/l oil	.34
5.	Current oil costs ($/yr)	918
6.	Extra labour costs ($/yr)	0
7.	% Mtnc costs	2
7.1	Extra maintenance costs ($/yr)	
	5a	24
	5b	0
	5c	0
8.	% other energy use	25
8.1	Cost ($/yr)	229.5
9.	COSP Grant $	
	5a	0
	5b	0
	5c	0
10.	Net plant cost ($)	
	5a	1200
	5b	0
	5c	0
11.	Required IRR	.2
12.	# yrs plant life (n)	10
13.	Plant salvage value @ n yrs,% & $	0
	5a	0
	5b	0
	5c	0
14.	PVIF(a)IRR n	4.192472086
15.	NPV,yr n,IRR	.1615055829
16.	Tax rate	0
17.	% oil combus	.8
18.	Heat content oil (J/l)	38700000
19.	% wood subs	.75
20.	Heat content wood (J/t)	20000000000
21.	% wood combustion@% H2o	.5
22.	%H20 in wood	.3
23.	Wood fuel required (bdt/yr)	6.27

Calculate maximum cost of wood fuel ; given above criteria

	CASE 5a Debit	ROUND WOOD Credit
1.Plant cost	1200.00	
2.Fuel saving		2886.52
3.P.V. maintenance	100.62	
4.P.V. CCA		0.00
5.P.V. salvage		0.00
6.P.V. loss on salvage CCA	0.00	
7.P.V. extra labour	0.00	
	1300.62	2886.52

Maximum price / bdt of wood fuel delivered = 60.34

DETERMINATION OF WOOD FUEL SALES PRICE LIMITS

CASE 5: RESIDENTIAL, OPTIMISTIC CASE

NGL JOB 3071
3071case5b
83-06-28

INPUT DATA & BASIC ASSUMPTIONS

		CASE 5a
1.	Plant cost	
	5a	1200
	5b	0
	5c	0
2.	Plant size (MJ/hr)	50
3.	Existing oil use/year (l)	2700
4.	$/l oil	.34
5.	Current oil costs ($/yr)	918
6.	Extra labour costs ($/yr)	0
7.	% Mtnc costs	2
7.1	Extra maintenance costs ($/yr)	
	5a	24
	5b	0
	5c	0
8.	% other energy use	25
8.1	Cost ($/yr)	229.5
9.	COSP Grant $	
	5a	600
	5b	0
	5c	0
10.	Net plant cost ($)	
	5a	600
	5b	0
	5c	0
11.	Required IRR	.15
12.	# yrs plant life (n)	10
13.	Plant salvage value @ n yrs,% & $	0
	5a	0
	5b	0
	5c	0
14.	PVIF(a,IRR n	5.018768627
15.	NPV,yr n,IRR	.2471847061
16.	Tax rate	0
17.	% oil combus	.8
18.	Heat content oil (j/l)	38700000
19.	% wood subs	.75
20.	Heat content wood (j/t)	20000000000
21.	% wood combustion@% H2o	.5
22.	%H20 in wood	.3
23.	Wood fuel required (bdt/yr)	6.27

Calculate maximum cost of wood fuel ; given above criteria

	CASE 5a Debit	ROUND WOOD Credit
1.Plant cost	600.00	
2.Fuel saving		3455.42
3.P.V. maintenance	120.45	
4.P.V. CCA		0.00
5.P.V. salvage		0.00
6.P.V. loss on salvage CCA	0.00	
7.P.V. extra labour	0.00	
	720.45	3455.42

Maximum price / bdt of wood fuel delivered = 86.92

APPENDIX I

Case VI: Agricultural

1. Description

Agricultural operation raising poultry. An oil fired boiler provides hot water for space and make-up air heating on a 24 hour per day, 7 day per week, 52 weeks per year basis. The heating load varies with the ambient air temperature.

2. Assumptions

A new wood fuel boiler is installed using hogged bark and wood chips to supply 70% of the heating requirements.

DETERMINATION OF WOOD FUEL SALES PRICE LIMITS

CASE 6: AGRICULTURAL, PESSIMISTIC CASE

NGL JOB 3071
3071case6w
83-06-28

INPUT DATA & BASIC ASSUMPTIONS

1. Plant cost		9. FIRE Grant $			
6a	57000	6a	1[illegible]		
6b	57000	6b	1[illegible]		
6c	47800	6c	8604		
2. Plant size (MJ/hr)	500	10. Net plant cost ($)			
		6a	46740		
		6b	46740		
3. Existing oil use/year (l)	113500	6c	39196		
		11. Required IRR	.2		
4. $/l oil	.32	12. # yrs plant life (n)	10		
5. Current oil costs ($/yr)	36320				
		13. Plant salvage value @ n yrs,% & $			
6. Extra labour costs ($/yr)	0	6a	22800		
		6b	22800		
		6c	19120		
7. % Mtnc costs	2	14. PVIF(a)IRR n	4.192472086		
7.1 Extra maintenance costs ($/yr)		15. NPV,yr n,IRR	.1615055829		
6a	1140				
6b	1140				
6c	356	16. Tax rate	.5		
8. % oil use	30		.5		
8.1 Future oil use ($/yr)	10896				

	CASE 6a	CASE 6b	CASE 6c
17. % oil combus	.8	.8	.8
18. Heat content oil (j/l)	38700000	38700000	38700000
19. % wood subs	.7	.7	.7
20. Heat content wood (j/t)	20000000000	20000000000	20000000000
21. % wood combustion@% H2o	.6	.71	.73
22. %H20 in wood	.5	.2	.1
23. Wood fuel required (bdt/yr)	204.38	173.22	168.48

Calculate maximum cost of wood fuel ; given above criteria

	CASE 6a WET CHIPS		CASE 6b DRY CHIPS		CASE 6c PELLETS	
	Debit	Credit	Debit	Credit	Debit	Credit
1.Plant cost	46740.00		46740.00		39196.00	
2.Fuel saving		53294.71		53294.71		53294.71
3.P.V. maintenance	2389.71		2389.71		2004.00	
4.P.V. CCA		11685.00		11685.00		9799.00
5.P.V. salvage		3682.33		3682.33		3087.99
6.P.V. loss on salvage CCA	920.58		920.58		772.00	
7.P.V. extra labour	0		0		0	
	50050.29	68662.03	50050.29	68662.03	41972.00	66181.69
Maximum price / bdt of wood fuel delivered =		43.31		51.26		68.55

DETERMINATION OF WOOD FUEL SALES PRICE LIMITS

CASE 6: AGRICULTURAL, OPTIMISTIC CASE

NGL JOB 3071
3071case6b
83-06-28

INPUT DATA & BASIC ASSUMPTIONS

1. Plant cost		
6a	49600	
6b	49600	
6c	41500	
2. Plant size (MJ/hr)	500	
3. Existing oil use/year (l)	113500	
4. $/l oil	.32	
5. Current oil costs ($/yr)	36320	
6. Extra labour costs ($/yr)	0	
7. % Mtnc costs	2	
7.1 Extra maintenance costs ($/yr)		
6a	992	
6b	992	
6c	830	
8. % oil use	30	
8.1 Future oil use ($/yr)	10896	
9. FIRE Grant $		
6a	8928	
6b	8928	
6c	7470	
10. Net plant cost ($)		
6a	40672	
6b	40672	
6c	34030	
11. Required IRR	.15	
12. # yrs plant life (n)	10	
13. Plant salvage value @ n yrs,% & $	40	
6a	19840	
6b	19840	
6c	16600	
14. PVIF(a)IRR n	5.018768627	
15. NPV,yr n,IRR	.2471847061	
16. Tax rate	.5	
	.5	

	CASE 6a	CASE 6b	CASE 6c
17. % oil combus	.8	.8	.8
18. Heat content oil (j/l)	38700000	38700000	38700000
19. % wood subs	.7	.7	.7
20. Heat content wood (j/t)	20000000000	20000000000	20000000000
21. % wood combustion@% H2o	.6	.71	.73
22. %H20 in wood	.5	.2	.1
23. Wood fuel required (bdt/yr)	204.98	173.22	168.48

Calculate maximum cost of wood fuel ; given above criteria

	CASE 6a WET CHIPS Debit	CASE 6a WET CHIPS Credit	CASE 6b DRY CHIPS Debit	CASE 6b DRY CHIPS Credit	CASE 6c PELLETS Debit	CASE 6c PELLETS Credit
1.Plant cost	40672.00		40672.00		34030.00	
2.Fuel saving		63798.59		63798.59		63798.59
3.P.V. maintenance	2489.31		2489.31		2082.79	
4.P.V. CCA		11620.57		11620.57		9722.86
5.P.V. salvage		4904.14		4904.14		4103.27
6.P.V. loss on salvage CCA	1401.18		1401.18		1172.36	
7.P.V. extra labour	0		0		0	
	44562.49	80323.30	44562.49	80323.30	37285.15	77624.71
Maximum price / bdt of wood fuel delivered =		69.52		82.27		95.42

APPENDIX I

Case VII: Agricultural

1. Description

An agricultural operation raising poultry on a year round basis and using an oil fired hot water furnace to provide space heat for the poultry barns.

2. Assumptions

A new hogged bark and wood chip fired hot water furnace is added to provide 70% of the heating requirements. A 12 hour automatic fuel hopper is provided which is loaded twice a day at peak condiitons using a farm tractor. No additional labour is required.

DETERMINATION OF WOOD FUEL SALES PRICE LIMITS

CASE 7: AGRICULTURAL, PESSIMISTIC CASE

NGL JOB 3071
3071case7w
83-06-28

INPUT DATA & BASIC ASSUMPTIONS

1. Plant cost		
7a	38200	
7b	38200	
7c	32000	
2. Plant size (MJ/hr)	250	
3. Existing oil use/year (l)	55000	
4. $/l oil	.34	
5. Current oil costs ($/yr)	18700	
6. Extra labour costs ($/yr)	0	
7. % Mtnc costs	2	
7.1 Extra maintenance costs ($/yr)		
7a	764	
7b	764	
7c	640	
8. % oil use	30	
8.1 Future oil use ($/yr)	5610	
9. FIRE Grant $		
7a	6876	
7b	6876	
7c	5760	
10. Net plant cost ($)		
7a	31324	
7b	31324	
7c	26240	
11. Required IRR	.15	
12. # yrs plant life (n)	10	
13. Plant salvage value @ n yrs,% & $	40	
7a	15280	
7b	15280	
7c	12800	
14. PVIF(a)IRR n	5.018768627	
15. NPV,yr n,IRR	.247184706	
16. Tax rate	.5	.5

	CASE 7a	CASE 7b	CASE 7c
17. % oil combus	.3	.8	.8
18. Heat content oil (j/l)	38700000	38700000	38700000
19. % wood subs	.7	.7	.7
20. Heat content wood (j/t)	20000000000	20000000000	20000000000
21. % wood combustion@% H2o	.6	.71	.73
22. %H2O in wood	.5	.2	.1
23. Wood fuel required (bdt/yr)	99.33	83.94	81.64

Calculate maximum cost of wood fuel ; given above criteria

	CASE 7a WET CHIPS Debit	CASE 7a WET CHIPS Credit	CASE 7b DRY CHIPS Debit	CASE 7b DRY CHIPS Credit	CASE 7c PELLETS Debit	CASE 7c PELLETS Credit
1.Plant cost	31324.00		31324.00		26240.00	
2.Fuel saving		32847.84		32847.84		32847.84
3.P.V. maintenance	1917.17		1917.17		1606.01	
4.P.V. CCA		8949.71		8949.71		7497.14
5.P.V. salvage		3776.98		3776.98		3163.96
6.P.V. loss on salvage CCA	1079.14		1079.14		903.99	
7.P.V. extra labour	0		0		0	
	34320.31	45574.54	34320.31	45574.54	28750.00	43508.95
Maximum price / bdt of wood fuel delivered =		45.15		53.43		72.84

DETERMINATION OF WOOD FUEL SALES PRICE LIMITS

CASE 7: AGRICULTURAL, OPTIMISTIC CASE

NGL JOB 3071
3071case7b
83-06-28

INPUT DATA & BASIC ASSUMPTIONS

1. Plant cost		
7a	33200	
7b	33200	
7c	27800	
2. Plant size (MJ/hr)	250	
3. Existing oil use/year (l)	55000	
4. $/l oil	.34	
5. Current oil costs ($/yr)	18700	
6. Extra labour costs ($/yr)	0	
7. % Mtnc costs	2	
7.1 Extra maintenance costs ($/yr)		
7a	664	
7b	664	
7c	556	
8. % oil use	30	
8.1 Future oil use ($/yr)	5610	
9. FIPE Grant $		
7a	5976	
7b	5976	
7c	5004	
10. Net plant cost ($)		
7a	27224	
7b	27224	
7c	22796	
11. Required IRR	.15	
12. # yrs plant life (n)	10	
13. Plant salvage value @ n yrs,% & $	40	
7a	13280	
7b	13280	
7c	11120	
14. PVIF a,IRR n	5.018768627	
15. NPV,yr n,IRR	.2471847061	
16. Tax rate	.5	
	.5	

	CASE 7a	CASE 7b	CASE 7c
17. % oil combus	.8	.8	.8
18. Heat content oil (j/l)	38700000	38700000	38700000
19. % wood subs	.7	.7	.7
20. Heat content wood (j/t)	20000000000	20000000000	20000000000
21. % wood combustion@% H2o	.6	.71	.73
22. %H2O in wood	.5	.2	.1
23. Wood fuel required (bdt/yr)	99.33	83.94	81.64

Calculate maximum cost of wood fuel : given above criteria

	CASE 7a WET CHIPS		CASE 7b DRY CHIPS		CASE 7c PELLETS	
	Debit	Credit	Debit	Credit	Debit	Credit
1.Plant cost	27224.00		27224.00		22796.00	
2.Fuel saving		32847.84		32847.84		32847.84
3.P.V. maintenance	1666.23		1666.23		1395.22	
4.P.V. CCA		7778.29		7778.29		6513.14
5.P.V. salvage		3282.61		3282.61		2748.69
6.P.V. loss on salvage CCA	937.89		937.89		785.34	
7.P.V. extra labour	0		0		0	
	29828.12	43908.74	29828.12	43908.74	24976.56	42109.68
Maximum price / bdt of wood fuel delivered =		56.49		66.85		83.63

Appendix 2

Fuel Supply Data

Appendix 2

Table 2.1 Wood Residue From Sawmills

Kings & Queens Counties

Bone Dry Tonnes/Year

Company	Annual Production MFbm	Chips	Sawdust	Shavings	Bark	Slabs With Bark On
A	2,000	2,200	800	-	900	-
B	3,000	3,300	1,200	750	1,350	-
C	15,000	16,500	6,000	3,750	6,750	-
D	5,500	6,050	2,200	-	2,475	-
E	1,680	-	672	420	-	2,604
F	4,500	4,950	1,800	-	2,025	-
G	1,320	-	528	165	-	2,044
Totals	33,000	33,000	13,200	5,085	13,500	4,648

Appendix 2

Table 2.2

Land Area Classification - Region 3

Hectares x 1000

Condition Class		Private Land		Crown Land	Total
		Small Freehold	Large Freehold		
PROVINCIAL LAND		952.6	128.0	543.6	1624.2
FOREST LAND		772.2	125.4	515.8	1413.4
PRODUCTIVE FOREST		749.8	120.7	481.6	1352.1
Cover Type	S	151.1	38.5	208.9	398.5
	SH	207.0	32.8	102.1	341.9
	HS	221.5	25.8	104.9	352.2
	H	99.4	19.5	56.6	175.5
Plantations		1.7	0.4	1.9	4.0
Cut		5.6	3.3	5.4	14.3
Burn		0.4	0	1.0	1.4
Old Field		63.1	0.4	0.8	64.3
NON-PRODUCTIVE		22.4	4.7	34.2	61.3
NON-FOREST LAND		180.4	2.6	27.8	210.8
WASTE LAND		20.7	0.6	17.4	38.7
CLEARED LAND		159.7	2.0	10.4	172.1
Cultivated		120.7	0.1	0.4	121.2
Occupied		39.0	1.9	10.0	50.9
FEDERAL LAND					27.4
TOTAL LAND					1651.6
WATER					56.4
TOTAL AREA					1708.0

SOURCE: New Brunswick Forest Inventory, Department of Natural Resources.

Appendix 3

Flow Diagrams

Appendix 4

Financial Data for Business Models

Appendix 4

Summary of Capital Costs

and Labour Requirements

MODEL 1: Wood Chip Supply Business

CAPITAL COSTS		
Buildings		
- Office	$ 35,000	
- Plant	Ø	
		$ 35,000
Mobile Equipment		
- Transportation	$ 30,000	
- Loader	100,000	
		$130,000
Process Equipment		
- Truck Scale	$150,000	
- Hog & Screen System	Ø	
- Drying System	Ø	
- Pelletizing System	Ø	
- Log Slasher & Splitter System	Ø	
		$150,000
Working Capital		$101,000
TOTAL		$416,000
LABOUR		
Manager	1	
Operators	1	

FIVE YEAR PROFORMA PROFIT PLAN

MODEL 1: WOOD CHIP SUPPLY BUSINESS

PESSIMISTIC CASE

YEAR		1	2	3	4	5
SALES VOLUME	BDt/Y	15850	16960	18147	19417	20776
SALES PRICE	$/BDt	43.00	46.01	49.23	52.68	56.36
TOTAL SALES	$	681550	780307	893373	1022823	1171030
RM COST	$/BDt	29.20	30.66	32.19	33.80	35.49
TOTAL RM COST	$	462820	519978	584196	656344	737402
RM TRANSPORT	$	122045	137118	154052	173077	194452
LOADER OP COST	$	12839	14424	16205	18207	20455
TOTAL VAR COST	$	597704	671520	754453	847627	952309
INSURANCE	$	630	662	695	729	766
POWER	$	1200	1272	1348	1429	1515
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	30000	31500	33075	34729	36465
LABOUR	$	22000	23100	24255	25468	26741
MAINTENANCE	$	12600	13230	13892	14586	15315
TOTAL FIX COST	$	66830	70188	73714	77418	81307
INTEREST	$	40396	44045	45600	44213	39432
INCOME	$	-23380	-5446	19606	53565	97981
DEPRECIATION	$	63000	50400	40320	32256	25805
TAXABLE INCOME	$	-86380	-55846	-20714	21309	72176
TAXES	$	0	0	0	5114	17322
NET PROFIT	$	-86380	-55846	-20714	16195	54854

FIVE YEAR PROFORMA PROFIT PLAN

MODEL 1: WOOD CHIP SUPPLY BUSINESS

PROBABLE CASE

YEAR		1	2	3	4	5
SALES VOLUME	BDt/Y	15850	16960	18147	19417	20776
SALES PRICE	$/BDt	55.00	58.85	62.97	67.38	72.09
TOTAL SALES	$	871750	998067	1142686	1308262	1497829
RM COST	$/BDt	29.20	30.66	32.19	33.80	35.49
TOTAL RM COST	$	462820	519978	584196	656344	737402
RM TRANSPORT	$	122045	137118	154052	173077	194452
LOADER OP COST	$	12839	14424	16205	18207	20455
TOTAL VAR COST	$	597704	671520	754453	847627	952309
INSURANCE	$	630	662	695	729	766
POWER	$	1200	1272	1348	1429	1515
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	30000	31500	33075	34729	36465
LABOUR	$	22000	23100	24255	25468	26741
MAINTENANCE	$	12600	13230	13892	14586	15315
TOTAL FIX COST	$	66830	70188	73714	77418	81307
INTEREST	$	40396	24211	13791	14757	15790
INCOME	$	166821	232148	300729	368460	448422
DEPRECIATION	$	63000	50400	40320	32256	25805
TAXABLE INCOME	$	103821	181748	260409	336204	422617
TAXES	$	24917	43620	65298	103878	147862
NET PROFIT	$	78904	138129	195111	232326	274755

FIVE YEAR PROFORMA PROFIT PLAN

MODEL 1: WOOD CHIP SUPPLY BUSINESS

OPTIMISTIC CASE

YEAR		1	2	3	4	5
SALES VOLUME	BDt/Y	15850	16960	18147	19417	20776
SALES PRICE	$/BDt	67.00	71.69	76.71	82.08	87.82
TOTAL SALES	$	1061950	1215827	1392000	1593701	1824628
RM COST	$/BDt	29.20	30.66	32.19	33.80	35.49
TOTAL RM COST	$	462820	519978	584196	656344	737402
RM TRANSPORT	$	122045	137118	154052	173077	194452
LOADER OP COST	$	12839	14424	16205	18207	20455
TOTAL VAR COST	$	597704	671520	754453	847627	952309
INSURANCE	$	630	662	695	729	766
POWER	$	1200	1272	1348	1429	1515
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	30000	31500	33075	34729	36465
LABOUR	$	22000	23100	24255	25468	26741
MAINTENANCE	$	12600	13230	13892	14586	15315
TOTAL FIX COST	$	66830	70188	73714	77418	81307
INTEREST	$	40396	12889	13791	14757	15790
INCOME	$	357021	461230	550042	653899	775221
DEPRECIATION	$	63000	50400	40320	32256	25805
TAXABLE INCOME	$	294021	410830	509722	621643	749416
TAXES	$	82406	141862	192198	249166	314203
NET PROFIT	$	211614	268968	317523	372477	435213

Appendix 4

Summary of Capital Costs

and Labour Requirements

MODEL 2: Sawmill Residue Supply Business

CAPITAL COSTS		
Buildings		
- Office	$ 35,000	
- Plant	80,000	
		$115,000
Mobile Equipment		
- Transportation	$ 30,000	
- Loader	100,000	
		$130,000
Process Equipment		
- Truck Scale	$150,000	
- Hog & Screen System	239,000	
- Drying System	0	
- Pelletizing System	0	
- Log Slasher & Splitter System	0	
		$389,000
Working Capital		$ 13,400
TOTAL		$647,400
LABOUR		
Manager	1	
Operators	1	

FIVE YEAR PROFORMA PROFIT PLAN

MODEL 2: SAWMILL RESIDUE SUPPLY BUSINESS

PESSIMISTIC CASE

YEAR		1	2	3	4	5
SALES VOLUME	BDt/Y	15850	16960	18147	19417	20776
SALES PRICE	$/BDt	43.00	46.01	49.23	52.68	56.36
TOTAL SALES	$	681550	780307	893373	1022823	1171030
RM COST	$/BDt	3.00	3.15	3.31	3.47	3.65
TOTAL RM COST	$	47550	53422	60020	67433	75760
RM TRANSPORT	$	122045	137118	154052	173077	194452
LOADER OP COST	$	25677	28848	32411	36414	40911
TOTAL VAR COST	$	195272	219388	246483	276923	311123
INSURANCE	$	1268	1331	1398	1468	1541
POWER	$	20400	21624	22921	24297	25755
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	30000	31500	33075	34729	36465
LABOUR	$	22000	23100	24255	25468	26741
MAINTENANCE	$	25360	26628	27959	29357	30825
TOTAL FIX COST	$	99428	104607	110058	115795	121832
INTEREST	$	58645	25172	1815	1942	2078
INCOME	$	328205	431139	535018	628163	735997
DEPRECIATION	$	126800	101440	81152	64922	51937
TAXABLE INCOME	$	201405	329699	453866	563241	684059
TAXES	$	48337	100567	163768	219440	280936
NET PROFIT	$	153068	229132	290098	343802	403123

FIVE YEAR PROFORMA PROFIT PLAN

MODEL 2: SAWMILL RESIDUE SUPPLY BUSINESS

PROBABLE CASE

YEAR		1	2	3	4	5
SALES VOLUME	BDt/Y	15850	16960	18147	19417	20776
SALES PRICE	$/BDt	55.00	58.85	62.97	67.38	72.09
TOTAL SALES	$	871750	998067	1142686	1308262	1497829
RM COST	$/BDt	3.00	3.15	3.31	3.47	3.65
TOTAL RM COST	$	47550	53422	60020	67433	75760
RM TRANSPORT	$	122045	137118	154052	173077	194452
LOADER OP COST	$	25677	28848	32411	36414	40911
TOTAL VAR COST	$	195272	219388	246483	276923	311123
INSURANCE	$	1268	1331	1398	1468	1541
POWER	$	20400	21624	22921	24297	25755
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	30000	31500	33075	34729	36465
LABOUR	$	22000	23100	24255	25468	26741
MAINTENANCE	$	25360	26628	27959	29357	30825
TOTAL FIX COST	$	99428	104607	110058	115795	121832
INTEREST	$	58645	12397	1815	1942	2078
INCOME	$	518405	661674	784331	913602	1062796
DEPRECIATION	$	126800	101440	81152	64922	51937
TAXABLE INCOME	$	391605	560234	703179	848680	1010858
TAXES	$	132077	217909	290668	364728	447277
NET PROFIT	$	259528	342325	412511	483952	563581

FIVE YEAR PROFORMA PROFIT PLAN

MODEL 2: SAWMILL RESIDUE SUPPLY BUSINESS

OPTIMISTIC CASE

YEAR		1	2	3	4	5
SALES VOLUME BDt/Y		15850	16960	18147	19417	20776
SALES PRICE $/BDt		67.00	71.69	76.71	82.08	87.82
TOTAL SALES	$	1061950	1215827	1392000	1593701	1824628
RM COST $/BDt		3.00	3.15	3.31	3.47	3.65
TOTAL RM COST	$	47550	53422	60020	67433	75760
RM TRANSPORT	$	122045	137118	154052	173077	194452
LOADER OP COST	$	25677	28848	32411	36414	40911
TOTAL VAR COST	$	195272	219388	246483	276923	311123
INSURANCE	$	1268	1331	1398	1468	1541
POWER	$	20400	21624	22921	24297	25755
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	30000	31500	33075	34729	36465
LABOUR	$	22000	23100	24255	25468	26741
MAINTENANCE	$	25360	26628	27959	29357	30825
TOTAL FIX COST	$	99428	104607	110058	115795	121832
INTEREST	$	58645	1696	1815	1942	2078
INCOME	$	708605	890135	1033644	1199041	1389595
DEPRECIATION	$	126800	101440	81152	64922	51937
TAXABLE INCOME	$	581805	788695	952492	1134119	1337657
TAXES	$	228889	334196	417569	510017	613618
NET PROFIT	$	352916	454499	534924	624103	724040

Appendix 4

Summary of Capital Costs

and Labour Requirements

MODEL 3: Dried Chip Supply Business

CAPITAL COSTS		
Buildings		
- Office	$ 35,000	
- Plant	224,000	
		$ 259,000
Mobile Equipment		
- Transportation	$ 30,000	
- Loader	100,000	
		$ 130,000
Process Equipment		
- Truck Scale	$150,000	
- Hog & Screen System	239,000	
- Drying System	696,000	
- Pelletizing System	0	
- Log Slasher & Splitter System	0	
		$1,085,000
Working Capital		$ 101,000
TOTAL		$1,575,000

LABOUR	
Manager	1
Operators	2

FIVE YEAR PROFORMA PROFIT PLAN

MODEL 3: DRIED CHIP SUPPLY BUSINESS

PROBABLE CASE

YEAR		1	2	3	4	5
SALES VOLUME	BDt/Y	15850	16960	18147	19417	20776
SALES PRICE	$/BDt	65.00	69.55	74.42	79.63	85.20
TOTAL SALES	$	1030250	1179533	1350448	1546127	1770161
RM COST	$/BDt	29.20	30.66	32.19	33.80	35.49
TOTAL RM COST	$	509102	571976	642615	721978	811142
RM TRANSPORT	$	122045	137118	154052	173077	194452
LOADER OP COST	$	28245	31733	35652	40055	45002
TOTAL VAR COST	$	659392	740827	832319	935110	1050596
INSURANCE	$	2948	3095	3250	3413	3583
POWER	$	43200	45792	48540	51452	54539
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	30000	31500	33075	34729	36465
LABOUR	$	44000	46200	48510	50936	53482
MAINTENANCE	$	58960	61908	65003	68254	71666
TOTAL FIX COST	$	179508	188919	198828	209259	220241
INTEREST	$	144706	119452	127674	105729	75417
INCOME	$	46644	130335	191627	296030	423907
DEPRECIATION	$	294800	235840	188672	150938	120750
TAXABLE INCOME	$	-248156	-126005	2955	145092	303157
TAXES	$	0	0	709	34822	87057
NET PROFIT	$	-248156	-126005	2246	110270	216100

FIVE YEAR PROFORMA PROFIT PLAN

MODEL 3: DRIED CHIP SUPPLY BUSINESS

PESSIMISTIC CASE

YEAR		1	2	3	4	5
SALES VOLUME	BDt./Y	15850	16960	18147	19417	20776
SALES PRICE	$/BDt	51.00	54.57	58.39	62.48	66.85
TOTAL SALES	$	808350	925480	1059582	1213115	1388896
RM COST	$/BDt	29.20	30.66	32.19	33.80	35.49
TOTAL RM COST	$	509102	571976	642615	721978	811142
RM TRANSPORT	$	122045	137118	154052	173077	194452
LOADER OP COST	$	28245	31733	35652	40055	45002
TOTAL VAR COST	$	659392	740827	832319	935110	1050596
INSURANCE	$	2948	3095	3250	3413	3583
POWER	$	43200	45792	48540	51452	54539
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	30000	31500	33075	34729	36465
LABOUR	$	44000	46200	48510	50936	53482
MAINTENANCE	$	58460	61908	65003	68254	71666
TOTAL FIX COST	$	178508	188919	198828	209259	220241
INTEREST	$	144706	166580	187984	208095	225850
INCOME	$	-174546	-170846	-159548	-139348	-107791
DEPRECIATION	$	294800	235840	188672	150938	120750
TAXABLE INCOME	$	-479346	-406686	-348220	-290286	-228541
TAXES	$	0	0	0	0	0
NET PROFIT	$	-479346	-406686	-348220	-290286	-228541

FIVE YEAR PROFORMA PROFIT PLAN

MODEL 3: DRIED CHIP SUPPLY BUSINESS

OPTIMISTIC CASE

YEAR		1	2	3	4	5
SALES VOLUME BD†./Y		15850	16960	18147	19417	20776
SALES PRICE $./BD†		80.00	85.60	91.59	98.00	104.86
TOTAL SALES	$	1268000	1451733	1662089	1902926	2178660
RM COST	$./BD†	29.20	30.66	32.19	33.80	35.49
TOTAL RM COST	$	509102	571976	642615	721978	811142
RM TRANSPORT	$	122045	137118	154052	173077	194452
LOADER OP COST	$	28245	31733	35652	40055	45002
TOTAL VAR COST	$	659392	740827	832319	935110	1050596
INSURANCE	$	2948	3095	3250	3413	3583
POWER	$	43200	45792	48540	51452	54539
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	30000	31500	33075	34729	36465
LABOUR	$	44000	46200	48510	50936	53482
MAINTENANCE	$	58960	61908	65003	68254	71666
TOTAL FIX COST	$	179508	188919	198828	209259	220241
INTEREST	$	144706	111422	68088	16296	15790
INCOME	$	284394	410565	562855	742261	892033
DEPRECIATION	$	294800	235840	188672	150938	120750
TAXABLE INCOME	$	-10406	174725	374183	591323	771283
TAXES	$	0	41934	123209	233734	325333
NET PROFIT	$	-10406	132791	250974	357590	445950

Appendix 4

Summary of Capital Costs

and Labour Requirements

MODEL 4: Wood Pellet Supply Business

CAPITAL COSTS		
Buildings		
- Office	$ 35,000	
- Plant	464,000	
		$ 499,000
Mobile Equipment		
- Transportation	$ 30,000	
- Loader	100,000	
		$ 130,000
Process Equipment		
- Truck Scale	$150,000	
- Hog & Screen System	239,000	
- Drying System	696,000	
- Pelletizing System	705,000	
- Log Slasher & Splitter System	0	
		$1,790,000
Working Capital		$ 57,000
TOTAL		$2,476,000
LABOUR		
Manager	1	
Operators	3	

FIVE YEAR PROFORMA PROFIT PLAN

MODEL 4: WOOD PELLET SUPPLY BUSINESS

PESSIMISTIC CASE

YEAR		1	2	3	4	5
SALES VOLUME	BDt/Y	15850	16960	18147	19417	20776
SALES PRICE	$/BDt	69.00	73.83	79.00	84.53	90.44
TOTAL SALES	$	1093650	1252120	1433552	1641274	1879094
RM COST	$/BDt	16.10	16.91	17.75	18.64	19.57
TOTAL RM COST	$	280704	315370	354319	398077	447239
RM TRANSPORT	$	122045	137118	154052	173077	194452
LOADER OP COST	$	28245	31733	35652	40055	45002
TOTAL VAR COST	$	430993	484221	544022	611209	686693
INSURANCE	$	4838	5080	5334	5601	5881
POWER	$	106800	113208	120000	127201	134833
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	30000	31500	33075	34729	36465
LABOUR	$	66000	69300	72765	76403	80223
MAINTENANCE	$	96760	101598	106678	112012	117612
TOTAL FIX COST	$	304798	321110	338302	356421	375519
INTEREST	$	225207	182789	129736	67411	9827
INCOME	$	132652	264000	421493	606233	807055
DEPRECIATION	$	483800	387040	309632	247706	198164
TAXABLE INCOME	$	-351148	-123040	111861	358527	608890
TAXES	$	0	0	26847	115240	242675
NET PROFIT	$	-351148	-123040	85014	243287	366215

FIVE YEAR PROFORMA PROFIT PLAN

MODEL 4: WOOD PELLET SUPPLY BUSINESS

PROBABLE CASE

YEAR		1	2	3	4	5
SALES VOLUME	BDt/Y	15850	16960	18147	19417	20776
SALES PRICE	$/BDt	82.00	87.74	93.88	100.45	107.49
TOTAL SALES	$	1299700	1488027	1703642	1950499	2233127
RM COST	$/BDt	16.10	16.91	17.75	18.64	19.57
TOTAL RM COST	$	280704	315370	354319	398077	447239
RM TRANSPORT	$	122045	137118	154052	173077	194452
LOADER OP COST	$	28245	31733	35652	40055	45002
TOTAL VAR COST	$	430993	484221	544022	611209	686693
INSURANCE	$	4838	5080	5334	5601	5881
POWER	$	106800	113208	120000	127201	134833
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	30000	31500	33075	34729	36465
LABOUR	$	66000	69300	72765	76403	80223
MAINTENANCE	$	96760	101598	106678	112012	117612
TOTAL FIX COST	$	304798	321110	338302	356421	375519
INTEREST	$	225207	158063	80664	9184	9827
INCOME	$	338702	524633	740654	973685	1161087
DEPRECIATION	$	483800	387040	309632	247706	198164
TAXABLE INCOME	$	-145098	137593	431022	725979	962923
TAXES	$	0	33022	152140	302273	422878
NET PROFIT	$	-145098	104571	278882	423706	540045

FIVE YEAR PROFORMA PROFIT PLAN

MODEL 4: WOOD PELLET SUPPLY BUSINESS

OPTIMISTIC CASE

YEAR		1	2	3	4	5
SALES VOLUME	BDt/Y	15850	16960	18147	19417	20776
SALES PRICE	$/BDt	95.00	101.65	108.77	116.38	124.53
TOTAL SALES	$	1505750	1723933	1973731	2259725	2587159
RM COST	$/BDt	16.10	16.91	17.75	18.64	19.57
TOTAL RM COST	$	280704	315370	354319	398077	447239
RM TRANSPORT	$	122045	137118	154052	173077	194452
LOADER OP COST	$	28245	31733	35652	40055	45002
TOTAL VAR COST	$	430993	484221	544022	611209	686693
INSURANCE	$	4838	5080	5334	5601	5881
POWER	$	106800	113208	120000	127201	134833
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	30000	31500	33075	34729	36465
LABOUR	$	66000	69300	72765	76403	80223
MAINTENANCE	$	96760	101598	106678	112012	117612
TOTAL FIX COST	$	304798	321110	338302	356421	375519
INTEREST	$	225207	135092	41568	9184	9827
INCOME	$	544752	783510	1049839	1282910	1515119
DEPRECIATION	$	483800	387040	309632	247706	198164
TAXABLE INCOME	$	60952	396470	740207	1035205	1316955
TAXES	$	14628	134553	309516	459669	603080
NET PROFIT	$	46323	261917	430692	575536	713875

Appendix 4

Summary of Capital Costs

and Labour Requirements

MODEL 5: Fuel Wood Supply Business

CAPITAL COSTS		
Buildings		
- Office	$ 35,000	
- Plant	Ø	
		$ 35,000
Mobile Equipment		
- Transportation	$ 20,000	
- Loader	30,000	
		$ 50,000
Process Equipment		
- Truck Scale	Ø	
- Hog & Screen System	Ø	
- Drying System	Ø	
- Pelletizing System	Ø	
- Log Slasher & Splitter System	80,000	
		$ 80,000
Working Capital		$100,000
TOTAL		$265,000
LABOUR		
Manager	1	
Operators	2	

FIVE YEAR PROFORMA PROFIT PLAN

MODEL 5: FUEL WOOD SUPPLY BUSINESS

PESSIMISTIC CASE

YEAR		1	2	3	4	5
SALES VOLUME BDt/Y		8400	8988	9617	10290	11011
SALES PRICE $/BDt		61.00	65.27	69.84	74.73	79.96
TOTAL SALES	$	512400	586647	671652	768974	880399
RM COST	$/BDt	35.00	36.75	38.59	40.52	42.54
TOTAL RM COST	$	308700	346824	389657	437780	491846
RM TRANSPORT	$	64680	72668	81642	91725	103053
LOADER OP COST	$	42000	47187	53015	59562	66918
TOTAL VAR COST	$	415380	466679	524314	589067	661817
INSURANCE	$	330	347	364	382	401
POWER	$	3000	3180	3371	3573	3787
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	30000	31500	33075	34729	36465
LABOUR	$	44000	46200	48510	50936	53482
MAINTENANCE	$	6600	6930	7277	7640	8022
TOTAL FIX COST	$	84330	88581	93046	97736	102663
INTEREST	$	26862	29403	30065	28210	23832
INCOME	$	-14172	1983	24227	53961	92086
DEPRECIATION	$	33000	26400	21120	16896	13517
TAXABLE INCOME	$	-47172	-24417	3107	37065	78569
TAXES	$	0	0	746	8896	18857
NET PROFIT	$	-47172	-24417	2361	28169	59713

FIVE YEAR PROFORMA PROFIT PLAN

MODEL 5: FUEL WOOD SUPPLY BUSINESS

PROBABLE CASE

YEAR		1	2	3	4	5
SALES VOLUME	BDt/Y	8400	8988	9617	10290	11011
SALES PRICE	$/BDt	74.00	79.18	84.72	90.65	97.00
TOTAL SALES	$	621600	711670	814791	932854	1068025
RM COST	$/BDt	35.00	36.75	38.59	40.52	42.54
TOTAL RM COST	$	308700	346824	389657	437780	491846
RM TRANSPORT	$	64680	72668	81642	91725	103053
LOADER OP COST	$	42000	47187	53015	59562	66918
TOTAL VAR COST	$	415380	466679	524314	589067	661817
INSURANCE	$	330	347	364	382	401
POWER	$	3000	3180	3371	3573	3787
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	30000	31500	33075	34729	36465
LABOUR	$	44000	46200	48510	50936	53482
MAINTENANCE	$	6600	6930	7277	7640	8022
TOTAL FIX COST	$	84330	88581	93046	97736	102563
INTEREST	$	26862	18086	13753	14715	15745
INCOME	$	95028	138324	183678	231336	287799
DEPRECIATION	$	33000	26400	21120	16896	13517
TAXABLE INCOME	$	62028	111924	162558	214440	274282
TAXES	$	14887	26862	39014	51465	72360
NET PROFIT	$	47141	85062	123544	162974	201923

FIVE YEAR PROFORMA PROFIT PLAN

MODEL 5: FUEL WOOD SUPPLY BUSINESS

OPTIMISTIC CASE

YEAR		1	2	3	4	5
SALES VOLUME	BDt/Y	8400	8988	9617	10290	11011
SALES PRICE	$/BDt	88.00	94.16	100.75	107.80	115.35
TOTAL SALES	$	739200	846310	968940	1109340	1270083
RM COST	$/BDt	35.00	36.75	38.59	40.52	42.54
TOTAL RM COST	$	308700	346824	389657	437780	491846
RM TRANSPORT	$	64680	72668	81642	91725	103053
LOADER OP COST	$	42000	47187	53015	59562	66918
TOTAL VAR COST	$	415380	466679	524314	589067	661817
INSURANCE	$	330	347	364	382	401
POWER	$	3000	3180	3371	3573	3787
TELEPHONE	$	400	424	449	476	505
ADMINISTRATION	$	30000	31500	33075	34729	36465
LABOUR	$	44000	46200	48510	50936	53482
MAINTENANCE	$	6600	6930	7277	7640	8022
TOTAL FIX COST	$	84330	88581	93046	97736	102663
INTEREST	$	26862	12853	13753	14715	15745
INCOME	$	212628	278197	337828	407821	489858
DEPRECIATION	$	33000	26400	21120	16896	13517
TAXABLE INCOME	$	179628	251797	316708	390925	476341
TAXES	$	43111	60915	93954	131731	175207
NET PROFIT	$	136517	190882	222754	259194	301133

Appendix 5

Abbreviations, Conversion Factors and Glossary of Terms

Appendix 5

1. Abbreviations

bbl	= barrels
BDt	= bone dry tonne
ha	= hectare
J	= joule
l	= litre
M.C.	= moisture content
MFBM	= thousand feet board measure
N/A	= data not available

2. Prefixes

k — kilo	10^3
M — Mega	10^6
G — Giga	10^9
T — Tera	10^{12}

3. Conversion Factors

3.1 Length, Area, Volume, Mass

1 barrel	158.91 litres
1 bone dry tonne (wood)	2.0 tonnes (green condition)
1 cunit (wood)	100 cubic feet of solid wood
1 cunit (wood)	2.83 cubic meters
1 hectare	2.47 acres
1 tonne (metric)	1.1023 ton (short)
1 tonne (metric)	2205 pounds
1 tonne (metric)	1000 kilograms

3.2 Energy

1 barrel (furnace oil)	6.15×10^9 Joules
1 bone dry tonne (wood)	20.0×10^9 Joules
1 litre (furnace oil)	38.7×10^6 Joules
1 litre (furnace oil)	0.00258 bone dry tonnes of wood at efficiencies of 80% for oil and 60% for wood at 50% moisture content.

3.3 Sawmill Residues

1000 FBM	yields	1.1 bone dry tonnes of chips
1000 FBM	yields	0.4 bone dry tonnes of sawdust
1000 FBM	yields	0.45 bone dry tonnes of bark
1000 FBM	yields	0.25 bone dry tonnes of shavings

Note: these are average conversion factors. Actual conversion factors will vary with each sawmill depending on the equipment in the mill and the type of products produced.

4. Glossary of Terms

Bone Dry - wood having zero moisture content. See oven dry also.

Cord - a common measure of firewood and pulpwood equal to the volume of wood in round (not split or chipped) form that can be neatly stacked, with the individual pieces parallel to one another, in a pile 4 feet wide, 4 feet high and 8 feet long. The pile volume is 128 cubic feet.

Efficiency or Appliance Efficiency - the percentage or fraction of the chemical energy in the fuel actually converted to useful heat by the furnace or boiler.

Feller - Buncher - a forestry machine able to travel off road and used to fell the trees and assemble them in bunches for pick-up by a forwarder or skidder.

Forwarder - a rugged, four-wheel drive, forestry machine able to travel off road and used to transport trees from the felling area to roadside by carrying them clear of the ground on a flat bed or bunker.

Full Tree - tree, complete with crown and branches, removed from forest in one piece.

Fungi - a group of plants including mildews and molds that have no leaves, flowers or green colour and reproduce by means of spores.

Green Wood or Chips - undried, freshly cut wood or chips from a live tree.

Load Factor - the average output of a heating plant divided by the peak or maximum output of the heating plant. For example:

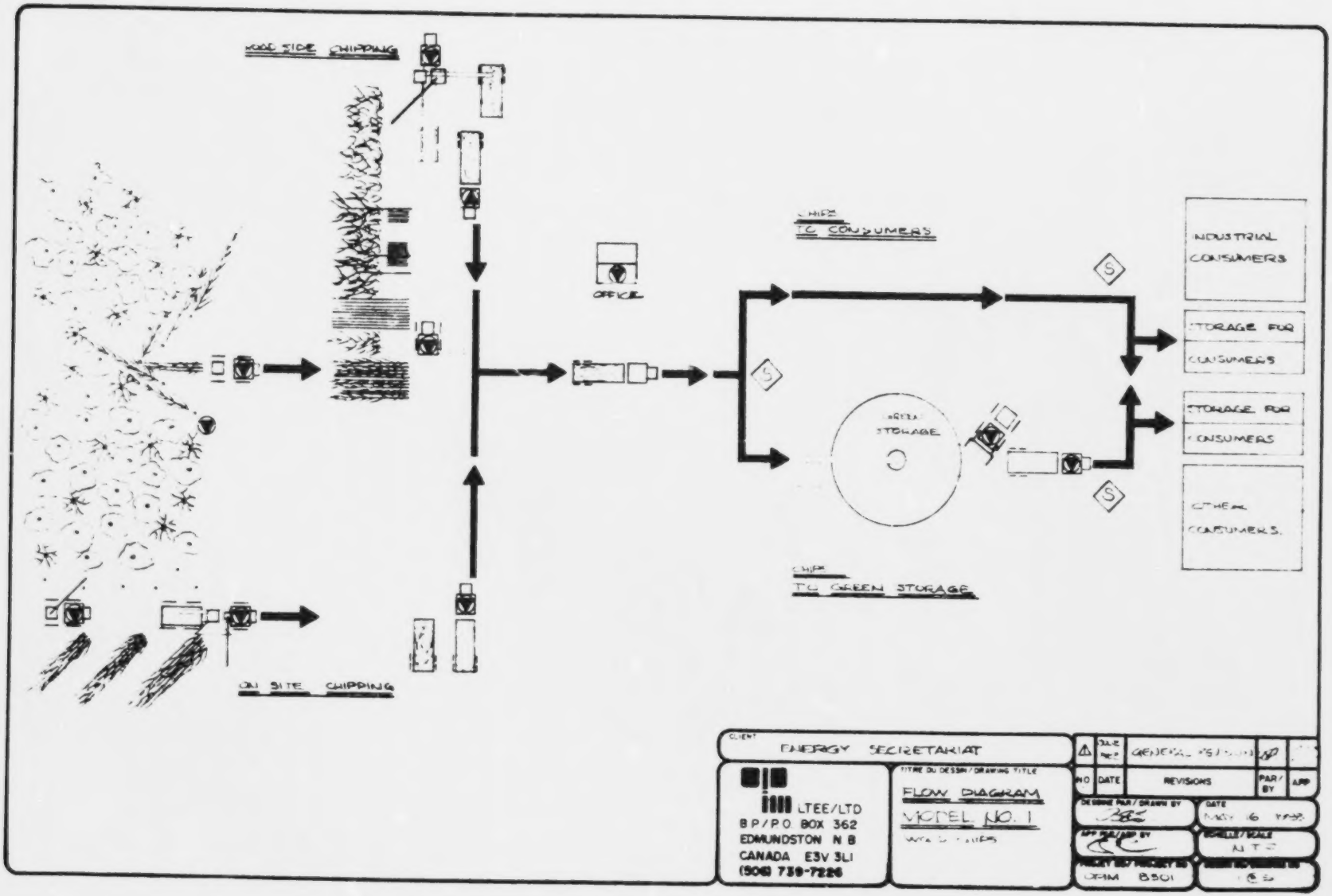
$$\text{Load Factor} = \frac{\dfrac{\text{(Total yearly heat output)}}{\text{(Operating hours per year)}}}{\text{Peak hourly heat output}}$$

Moisture Content (MC) - the fraction or percentage of water in wood as determined in a laboratory drying oven and calculated on either a dry or a wet basis. A wet basis moisture content is used in this report.

$$\text{MC(dry basis)} = \frac{\text{weight of water removed in oven drying}}{\text{oven dry weight of wood}} \times 100$$

$$\text{MC(wet basis)} = \frac{\text{weight of water removed in oven drying}}{\text{original weight of wood including its moisture}} \times 100$$

Ovendry Wood	- wood dried to constant weight at about 105°C and low humidity. By definition, wood with zero moisture content. Also called bone dry.
Processor	- a forestry machine able to travel off road. It is used to remove the tops and limbs from previously felled trees and cuts the tree into the lengths required for pulpwood, sawlogs, or fuelwood.
Pulp Wood	- a piece of wood 4 ft. or 8 ft. long to be used to produce woodpulp. Also called pulpstick.
Seasoned Wood	- wood which has lost a significant amount of its original (green) moisture. There is no universally accepted definition of the moisture content of such wood.
Skidder	- a rugged, articulated, four-wheel drive off-road forestry tractor equipped to permit it to drag or skid trees from the felling area to roadside or to a landing using a grapple or cables.
Slasher	- a forestry machine which cuts previously felled and delimbed trees into the lengths required for pulpwood, sawlogs or fuelwood.
Thinning, Pre-commercial	- removal of small trees with no conventional commercial value to improve growth of remaining trees.
Thinning, Commercial	- removal of trees large enough to be sold as pulpwood or fuel wood to improve growth of remaining stand.
Tree Length	- tree, with crown and branches removed, removed from forest in one piece.
Winch	- a device using a wire rope around a mechanically driven drum and attached to a skidder or farm tractor to enable trees or bundles of trees to be dragged from the felling site to roadside.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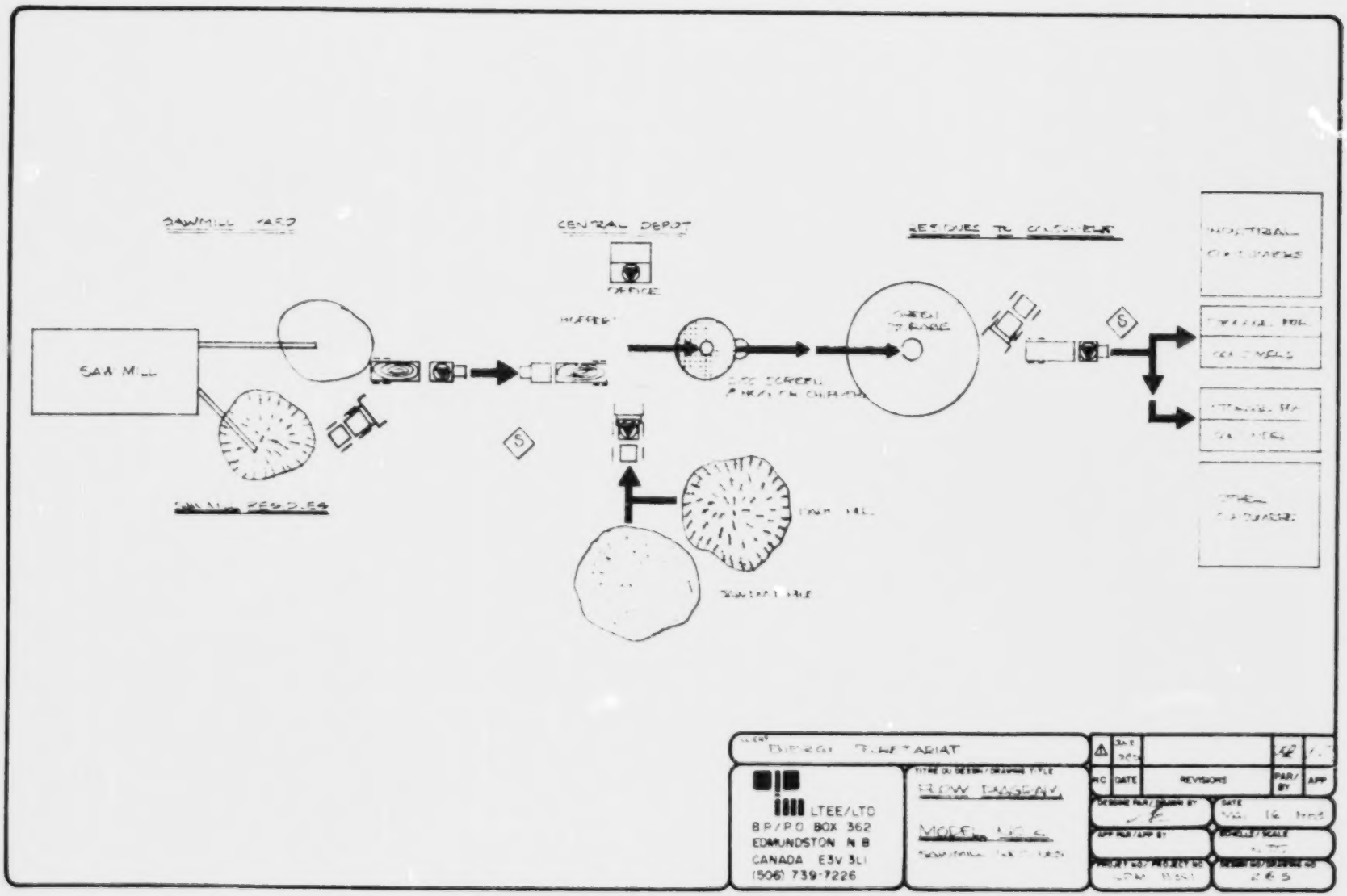
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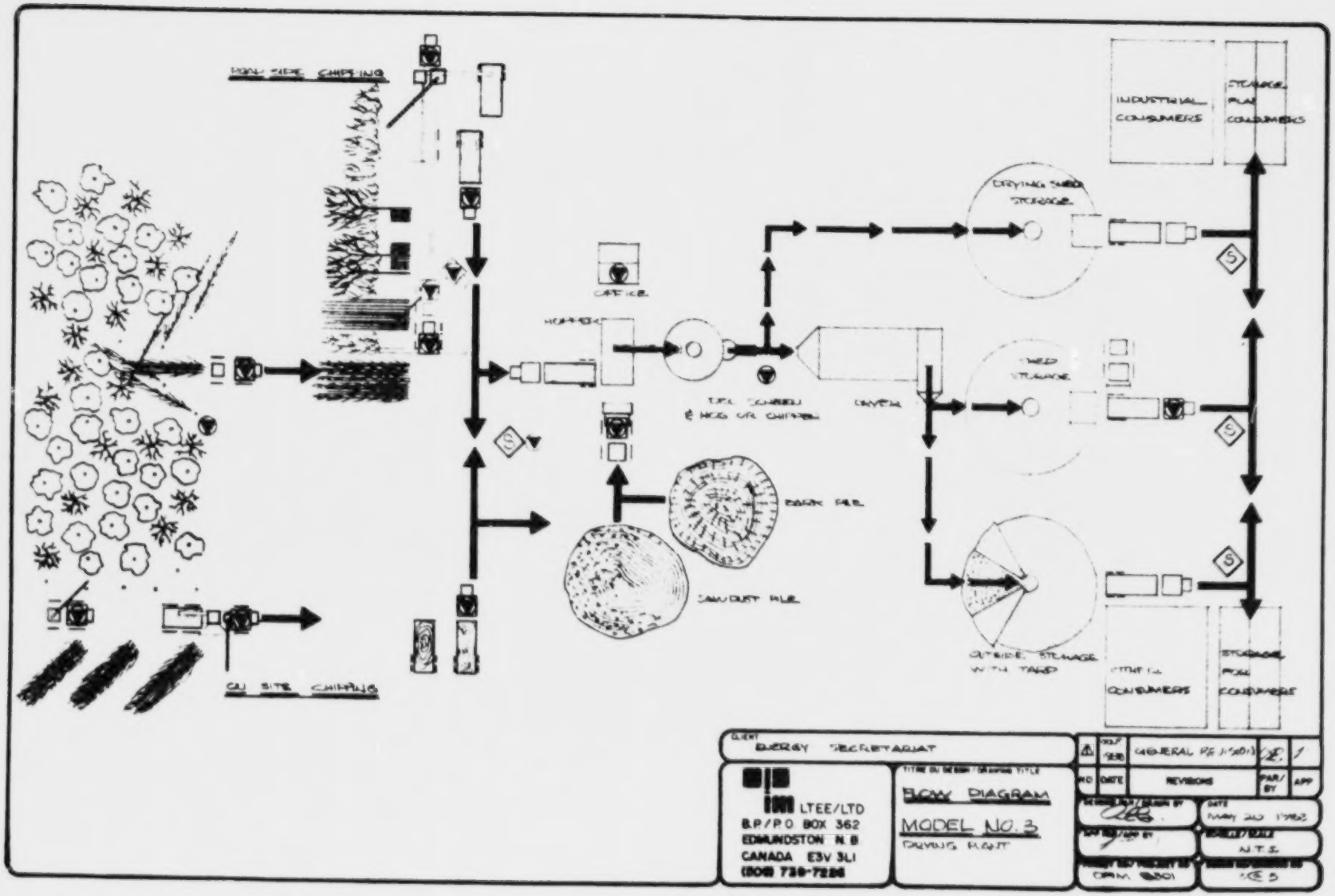
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BARK PILE
SAW DUST PILE
OUTSIDE STORAGE WITH YARD
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(506) 739-7286
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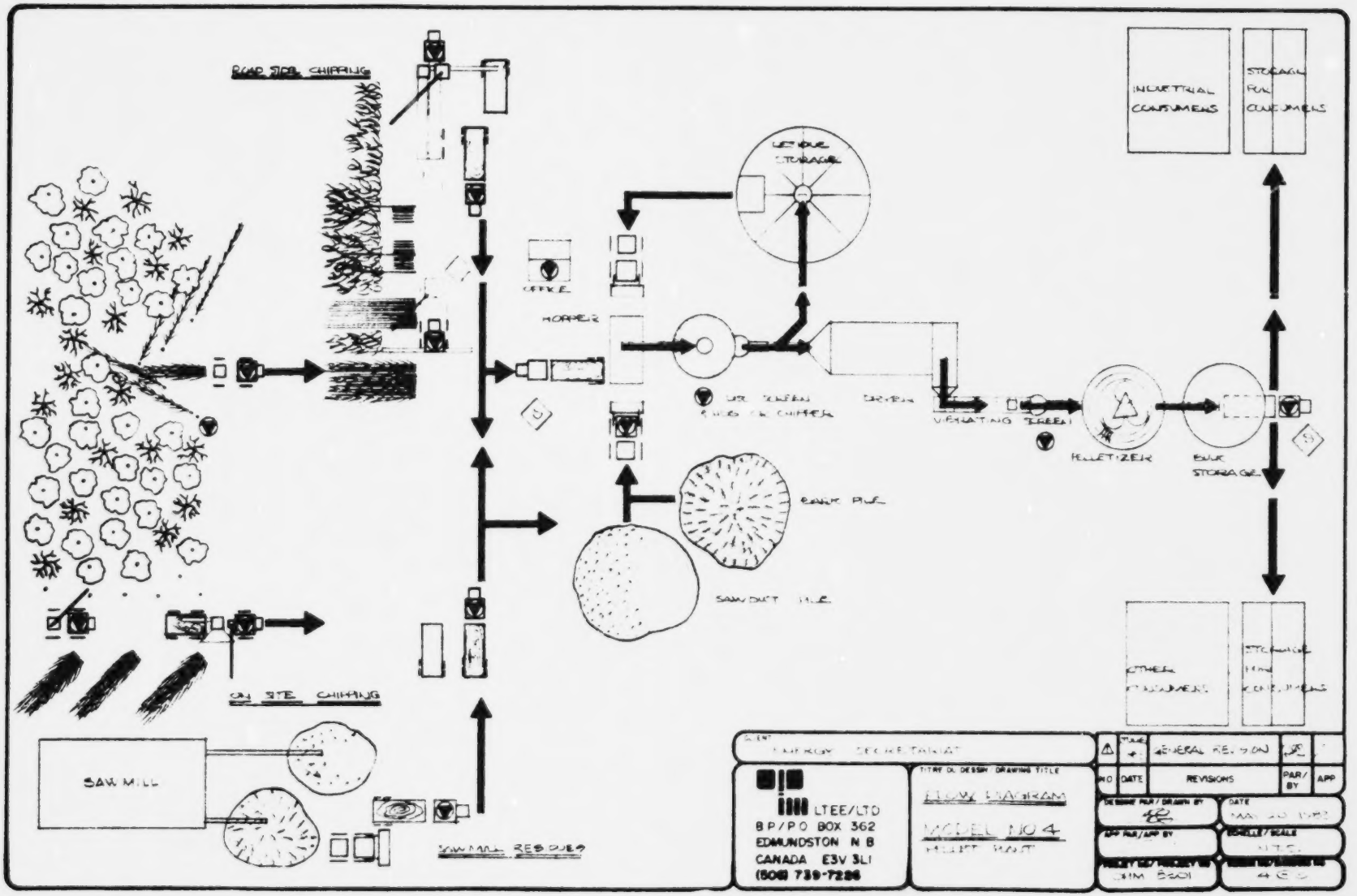
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PELLETIZER
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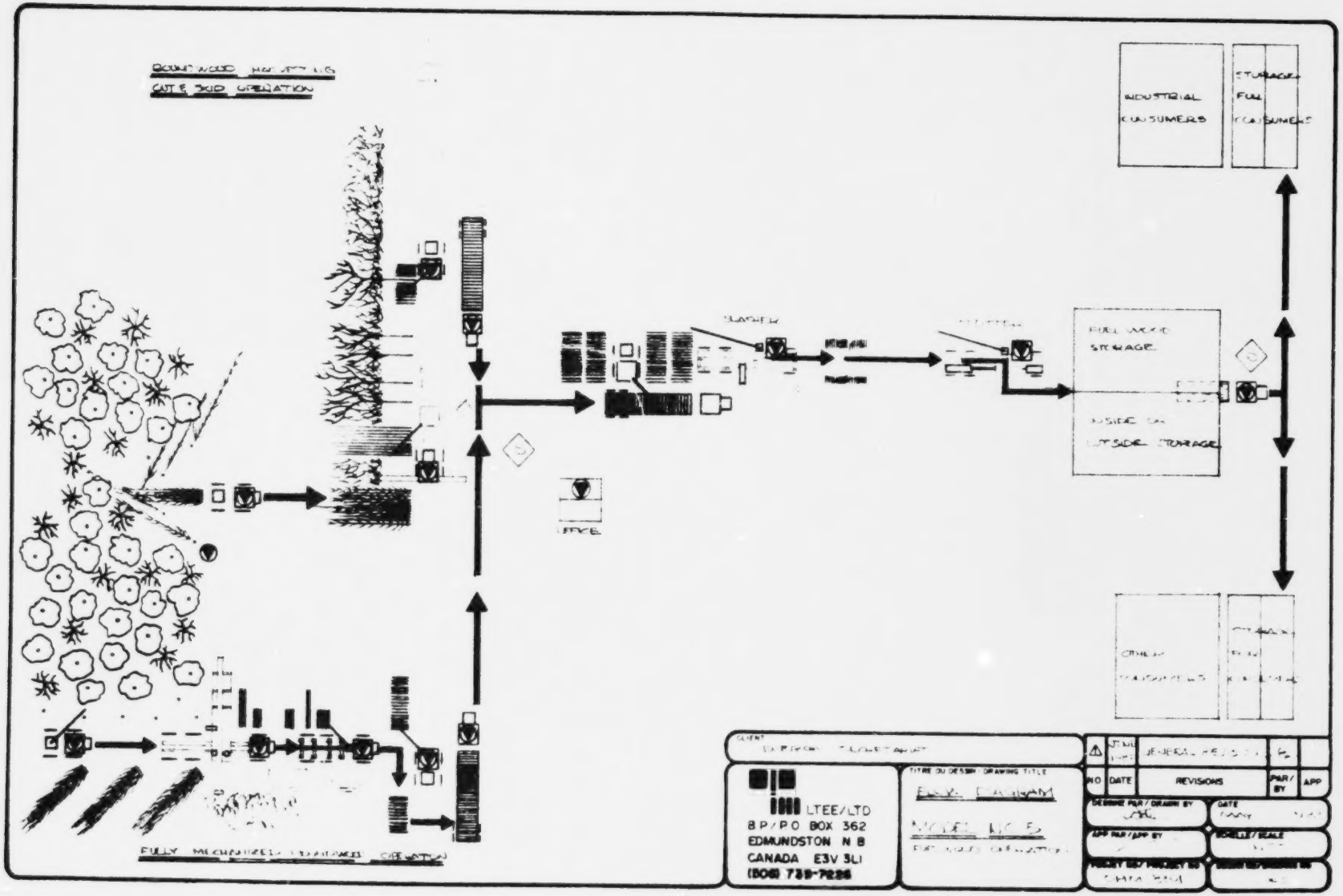
MODEL NO 4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